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High-pressure locomotives, (1)

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Figs. 1 to 17, pp. 379 to 405.

At no time during the history of the steam-locomotive have such radical changes been introduced as during the past ten years. These changes have been introduced more or less simultaneously in countries supplying the locomotives of the world, and have no doubt been stimulated by the competition of electricity and oil-engines which offered more efficient and in some cases cheaper motive power. Twenty years ago it was thought that the steam-locomotive had attained practically its maximum development, as it had nearly reached the limits imposed by the loading gauge.

The radical changes necessitated by the adoption of extra high pressures seem to have opened up a new era. Not only do these changes render possible an increase in tractive power, but they should at the same time increase the overall efficiency.

In Great Britain alone there are 23 000 locomotives, and a sum of approximately £45 000 000 per annum is spent on their maintenance, renewal, and running. Of this sum, nearly £12 000 000, or 25 %, is the cost of fuel burnt by these locomotives, and another £12 000 000 has to be spent on their maintenance and renewal. The purpose of the novel forms of locomotive which have been introduced during the last five years has been to effect economy principally in fuel consumption, but the Author wishes to draw attention to the importance of the cost of maintenance, and the necessity for designers of new and improved forms of high-pressure locomotives to remember that the expense incurred in maintaining locomotives is equal to the cost of the great quantity of coal which they consume. It will be seen what a large field there is for economy if both cost of fuel and maintenance can be reduced, and what an influence such economy can have on the cost of transportation on railways.

(1) Paper read by the Author at the Institution of Mechanical Engineers on 23 January 1931.

From the early days of the locomotive it has been recognized that increase of boiler pressure results in decrease of coal consumption, but with the conventional type of locomotive boiler this has generally resulted in increasing the cost of firebox repairs, and reducing the life of boilers and fireboxes. When the « Rocket » was built by George Stephenson, a boiler pressure of 50 lb. per sq. inch was employed, and pressures have gradually increased until now there are many engines running in this country with a boiler pressure of 250 lb. per sq. inch. Pressures up to 325 lb. per sq. inch have been experimentally tried for locomotives in Germany and America, but 250 lb. per sq. inch can be looked upon as approximately the maximum pressure which can be carried in a boiler of the Stephenson type, having regard to the cost of boiler maintenance.

It has taken 100 years to increase the pressure of locomotives from 50 lb. to 250 lb. per sq. inch, but during the last five years pressures have leapt up to 450, 900, and now to 1 700 lb. per sq. inch.

The use of pressures above 250 lb. per sq. inch has necessitated the design of a completely novel form of boiler built up of tubes and circular drums in which, generally, all flat surfaces have been eliminated. Ingenious means have been adopted for transmitting the heat from the fire to the water. The use of very high pressures, and the consequent high temperature, result in conditions which are much more exacting to the materials used in the construction of the boilers. These conditions are aggravated unless the heat transference is very rapid.

In striving for economy by the use of higher pressure, designers of locomotives are only following the lead which has been set by the designers of large stationary plants and marine engines. Their problem, however, has been made more difficult by loading-gauge and weight restrictions, and for these reasons they are unable to take advantage of condensers and have had to extend the pressure gradient upwards to a greater extent. It does not necessarily follow that the use of high pressures in boilers is more dangerous than that of low pressures. An explosion of a boiler at a pressure of 50 lb. per sq. inch can have disastrous results, and there is no reason, if proper precautions are taken both in design and maintenance, to assume that there is any greater liability to explosion or failure as a consequence of increase in pressure.

Whilst high steam pressure gives greater economy in fuel consumption, it demands complication in design, and care must be taken that the economies in fuel are not absorbed in the increased cost of maintenance of the boiler and of the machine as a whole. Simplicity of design is an important factor, because simplicity generally results in accessibility. Time alone can prove which of the designs, if any, that have been recently produced, will result in such overhead economies as will justify their general adoption. The results which may reasonably be expected from the use of high steam-pressures on locomotives are so attractive that encouragement should be given to the production and development of designs by which these results can be attained.

Reciprocating pistons have been adopted in all the latest high-pressure locomotives, as this form of conversion of energy appears to be the most advantageous for meeting all conditions which a locomotive is required to fulfil. It is interesting to note that in the high-pressure locomotives which have been produced during the last five years, both two-, three-, and four-cylinder compounds have been adopted. The Author proposes to de-

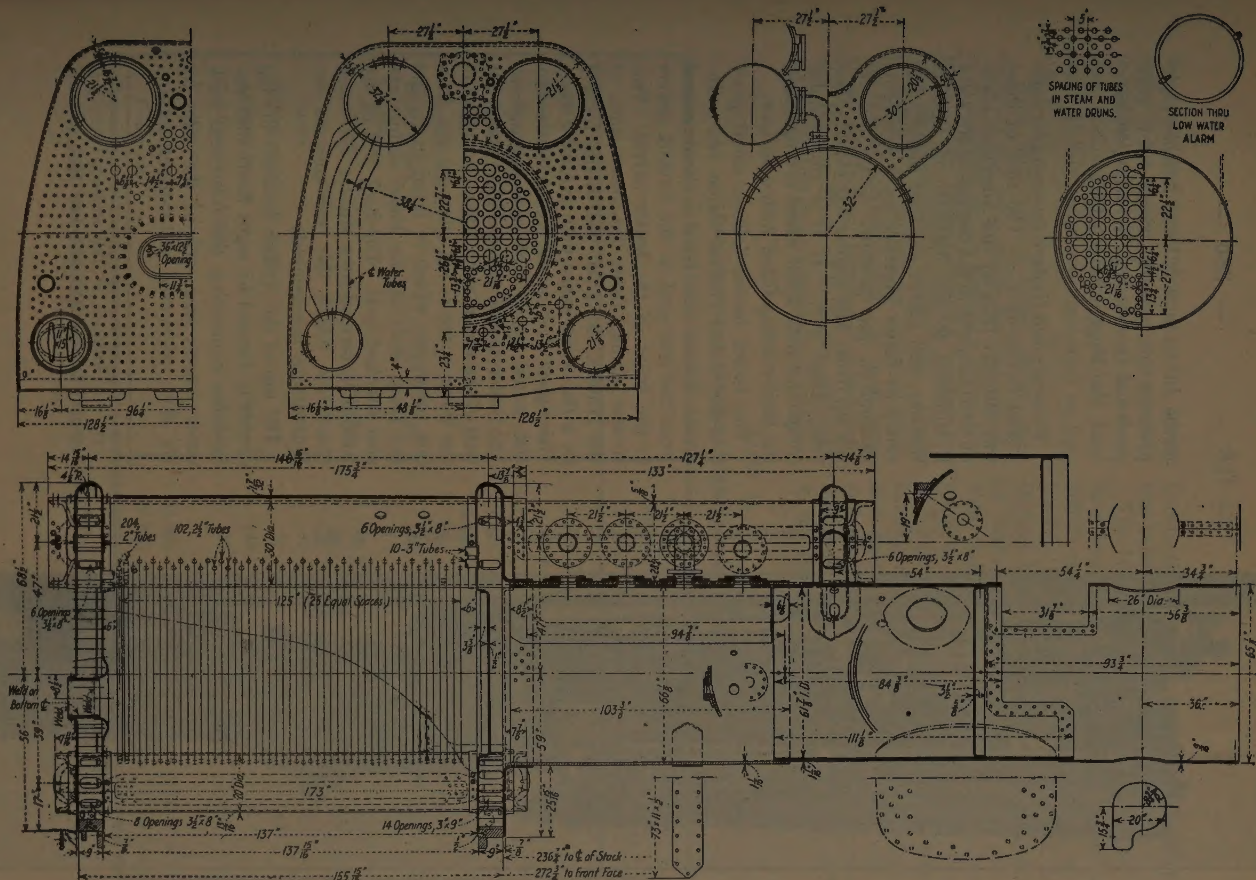


Fig. 1. — Elevations and cross-sections of high-pressure boiler with water-tube firebox, Delaware and Hudson 2-8-0 compound locomotive « Horatio Allen ».

scribe in some detail the notable high-pressure locomotives which have been produced in America, Germany, Switzerland, and England since 1924.

Delaware and Hudson two-cylinder compound locomotives. — The first of these was built in 1924 by the American Locomotive Company to the designs of Mr. John E. Muhlfeld, for the Delaware & Hudson Railway, and marks the first distinct advance in boiler pressure on a main-line locomotive, the pressure being 350 lb. per sq. inch. The engine was called « Horatio Allen » [1]. It is a two-cylinder compound with 2-8-0 wheel arrangement, the tender being fitted with a booster.

The boiler barrel follows usual practice, but over it, on each side, two cylindrical drums are fixed. These extend from the rear end of the firebox nearly to the front of the boiler barrel. Two shorter drums form the lower sides of the firebox, the front wall being formed by a flat water space with ordinary stays. The upper drums are connected to this flat water space, and pass through it. The boiler barrel is secured to the front wall of the water space. The rear plate of the water space is cut away for the firebox tube-plate which is fixed in it, and the front ends of the lower drums are also attached to it. The back end of the firebox is formed by a similar flat water space into which the rear ends of the four drums are secured.

The top of the firebox between the top drums is formed by eight horizontal water-tubes connecting the front and back water spaces, and each of the sides by six rows of curved water-tubes joining

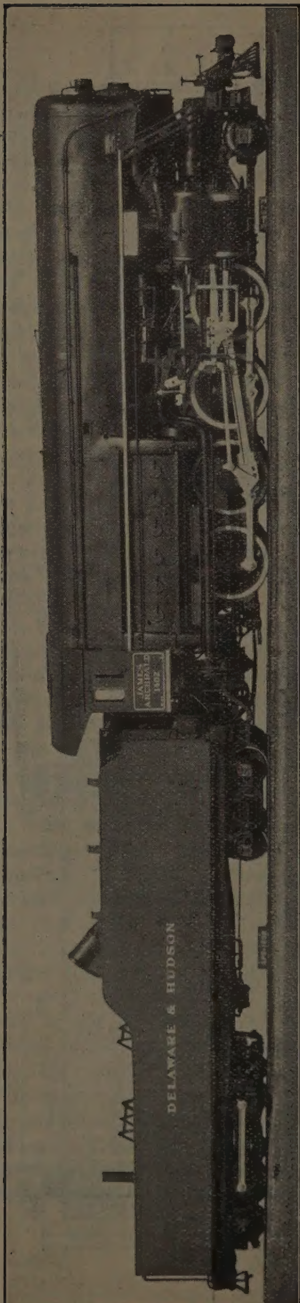


Fig. 2. — Delaware and Hudson Railway locomotive « James Archbald ».

(1) See *Bulletin of the Railway Congress*, February 1926, p. 130, and July 1930, p. 1692.

the upper and lower drums. The front ends of the upper drums are connected to the boiler barrel by headers, and four pipe connexions are also provided; sections of this boiler are illustrated in figure 1.

With this type of boiler about one-third of the evaporative heating surface is in the firebox. In ordinary locomotive boilers the firebox heating surface is only about one-tenth of the total. There is nothing of exceptional novelty about the rest of the locomotive. It must have given satisfaction, because the Delaware and Hudson Railway Company obtained a very similar engine from the American Locomotive Company early in 1927 which was called « John B. Jervis » (1).

The boiler is of very similar construction, but the pressure has been raised to 400 lb. per sq. inch, and a greater superheating surface given. The firebox is slightly larger, and it is covered by sheets of heat-resisting steel lagged on the outside, with hand-hole openings to allow ashes to be cleared from the fire-tubes and tops of the drums. The brick arch extends the entire length of the firebox, and causes the gases to flow outwards, and up through the side water-tubes into the combustion space above the arch, and to the fire-tubes.

TABLE 1.

Delaware and Hudson high-pressure locomotives.

—	*Horatio Allen.*	*John B. Jervis.*	*James Archbald.*
Date built	1924	1927	1930
Grate area . . . sq. feet.	71.4	82	82
Heating surface :			
Firebox . . . —	1 187	1 217	1 114
Total evaporative . . . —	3 200	3 121	3 439
Superheater . . . —	579	700	1 037
Boiler pressure . . . lb. per sq. inch.	350	400	500
Cylinders :			
Diameter, H.P. . . . inches.	23 1/2	22 1/4	20 1/2
— L.P. . . . —	41	38	35 1/2
Stroke . . . —	30	30	32
Driving-wheels, diameter . . . —	57	57	63
Adhesive weight . . . tons.	133	132	134
Total weight of engine . . . —	156	150	159
Tractive force :			
Simple . . . lb.	84 300	85 000	83 800
Compound . . . —	70 300	70 800	71 600

(1) See *Bulletin of the Railway Congress*, June 1927, p. 552, and July 1930, p. 1692.

The results obtained in advancing by progressive stages having proved satisfactory, the Delaware and Hudson Railway Company in 1930 produced a third engine in which the pressure was increased to 500 lb. per sq. inch, which was named « James Archbald » (1). This engine has a boiler of the same type as the previous engines, but its external appearance is noticeably different, the boiler being enclosed by an outside casting which effectively insulates and stream-lines the upper part. The superheating surface has been considerably increased, giving a steam temperature of 700° to 750° F. A photograph of this engine is shown in figure 2.

The main dimensions of these three locomotives are given in table 1.

The Schmidt-Henschel three-cylinder compound locomotive. — In 1926 one of the standard three-cylinder 4-6-0 engines of the German State Railways was converted by Messrs. Henschel and Sons, of Cassel, into a high-pressure locomotive (2). This engine was fitted with a multi-pressure type of boiler built to the design of the Schmidt Superheater Company, in which steam was produced at a pressure of 850 lb. per sq. inch by means of a closed circuit in which the heat transfer medium was distilled water. The design was the result of the invention and many years' investigation of the late Dr. Schmidt. A full description of this engine was given by Mr. R. P. Wagner, Chief Engineer of the German State Railways, before the Institution (3), in 1927, and only a brief account of the principle of its operation, therefore, is given in this paper.

In this system the tubes forming the walls of the firebox are filled with distilled water. They are subject to direct radiant heat, and owing to the purity of the water there is no corrosion or scaling to cause overheating of the tubes. The principle is illustrated diagrammatically in figure 3. The steam is generated in the firebox tubes at a pressure of 1 200 to 1 600 lb. per sq. inch, the pressure depending on the rate of firing. The steam passes through separating drums to the heat-transfer elements situated in the high-pressure drum. The difference in temperature between the saturated steam of 1 200 to 1 600 lb. pressure in the heat-transfer elements, and the water in the high-pressure drum at 850 lb. per sq. inch pressure causes the latent heat in the steam to evaporate the water. The steam in the closed circuit is condensed by the removal of its latent heat and returned as water by way of the down-pipes to the firebox bottom ring.

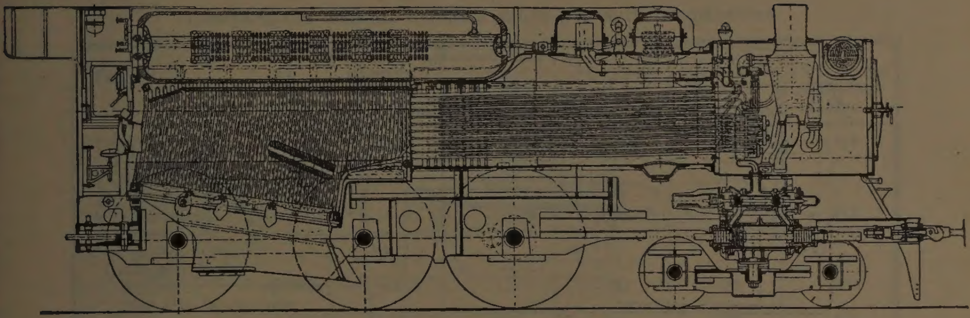
The boiler consists of two sections; one section generates the high-pressure steam at 850 lb. per sq. inch in a high-pressure drum by means of the closed circuit as described above, and the other section, which is similar to the barrel of an ordinary locomotive boiler, produces steam at about 200 lb. per sq. inch pressure. Figure 4 shows sections of this locomotive, and from these the design of the boiler can be seen. The high-pressure drum is a solid forging of about 3 feet internal diameter and is protected from the direct heat of the firebox gases by the cross-over tubes and by steel protection plates covered with asbestos sheets. The heating elements are inserted into the drum through a manhole at the rear end and consist of pipes 1 1/2 inches dia-

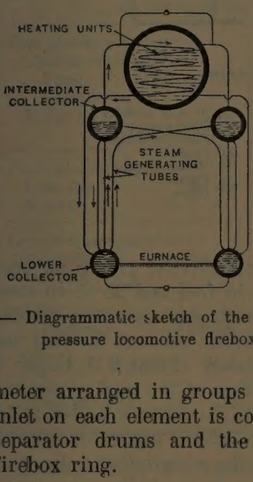
(1) See *Bulletin of the Railway Congress*, July 1930, p. 1697.

(2) See *Bulletin of the Railway Congress*, January 1930, p. 287.

(3) See *Proceedings, Institution of Mechanical Engineers*, 1927, vol. II, p. 961.

Fig. 4.





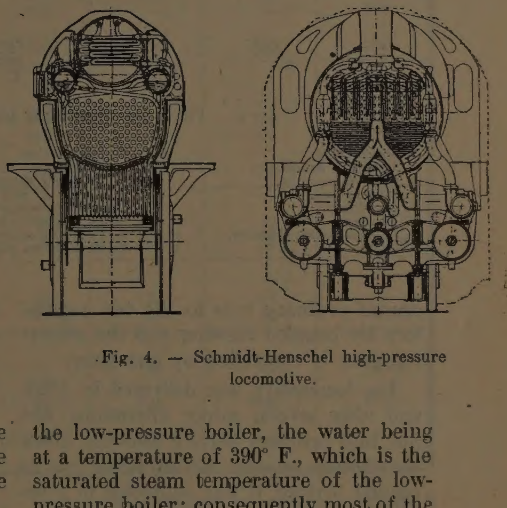


Fig. 3. — Diagrammatic sketch of the Schmidt high-pressure locomotive firebox.

Fig. 4. — Schmidt-Henschel high-pressure locomotive.

meter arranged in groups of coils. The inlet on each element is connected to the separator drums and the outlet to the firebox ring.

The low-pressure boiler has flues 3 1/4 inches outside diameter and nearly all these contain superheater elements. The flues at the top contain the low-pressure elements, and those at the bottom, elements for high-pressure steam. The water from the tender is fed into the low-pressure boiler by ordinary injectors or feed-pumps. The feed for the high-pressure drum is delivered by a pump from the low-pressure boiler, the water being at a temperature of 390° F., which is the saturated steam temperature of the low-pressure boiler; consequently most of the solid matter in the water has been deposited in the low-pressure boiler.

In operation, superheated steam from the high-pressure boiler enters the centre cylinder and exhausts into a receiver where it mixes with superheated steam from the low-pressure boiler, the combined steam passing to the low-pressure cylinders and so to the blast-pipe. The operation of the locomotive is similar to

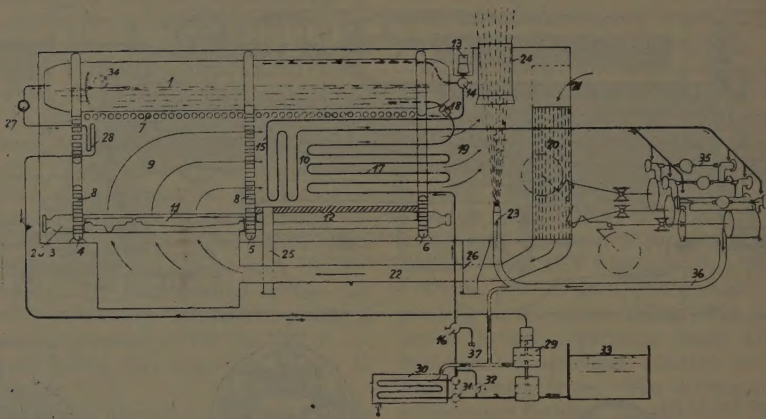


Fig. 5. — Winterthur high-pressure locomotive.

1. Steam-drum.
2, 3. Bottom drums.
4, 5. 6. Water-walls.
7. Water-tubes.
8. Stay-tubes.
9. Firebox.
10, 12. Combustion chamber.
11. Grate.
13. Safety-valve.
14. Regulator.
15, 28. Superheaters.
16, 27, 31, 32. Stop-valves.
17, 18. Main feed-heater and delivery.
19, 24. Smokebox and chimney.
20, 21, 22. Air-heater and dust.
23, 36. Exhaust pipe.
25, 26. Ash outlets.
29. Feed-pump.
30. Feed-preheater.
33. Tank.
34. Water-gauge.
35. Engine.
36. Drain.

one of ordinary type as the two regulators are coupled together and the reversing gear is controlled by one lever.

The locomotive was delivered in 1926, and after several minor alterations was put into ordinary service and has given satisfactory results. Before being put in regular service, it was subjected to a series of comparative trials with locomotives of the standard three-cylinder simple type as used for express trains on the German State Railways. The coal consumption per drawbar horse-power hour of the Schmidt engine was about 2.5 lb., and the steam consumption about 18 lb.

Since then certain modifications have been made resulting in further reduction of fuel and steam consumption to 2.15 lb. and 15 lb. respectively, giving an economy of 35 % in fuel and 23 % in steam as compared with engines of the standard type. The calorific value of the fuel used was approximately 12 600 B. T. U. per lb.

The proportion of the total power supplied by the high-pressure boiler at low output is 65 % and at higher output falls to 55 %. As the remainder of the steam is formed at ordinary boiler pressure, it is now appreciated that greater savings will be possible if a greater proportion can be generated at the higher pressure. In the latest designs the ratio has consequently been altered, the function of the low-pressure boiler becoming mainly that of a preheater and supplying only a very small proportion of the low-pressure steam.

TABLE 2.

Comparative data of Schmidt multi-pressure locomotives

Railway	German State Rys.	London Midland & Scottish.	New York Central.	Canadian Pacific.	Paris, Lyons & Mediterranean.
Type	4-6-0	4-6-0	4-8-4	2-10-4	4-8-2
Fuel	Coal.	Coal.	Coal.	Oil.	Coal.
Grate area . . . sq. feet.	26.6	28	70	77	41
High-pressure boiler :					
Heating surface :					
Firebox . . . sq. feet.	217.6	—	422	515	323
Heat-transfer elements sq. feet.	426	368	660	750	407
Superheater . . "	430	274	—	—	507
Boiler pressure lb. per sq. inch.	850	900	850	850	850
Low-pressure boiler :					
Heating surface :					
Flues. . . . sq. feet.	1 265	1 335	3 229	3 746	1 680
Superheater . . "	426	355	—	—	525
Boiler pressure lb. per sq. inch.	205	250	250	250	200
High-pressure cylinder :					
Diameter. . . . inches.	11.4	11.5	13	15.5	9.5
Stroke . . . "	24.8	26	30	28	25 6
Low-pressure cylinders :					
Diameter. . . . inches.	19.7	18	23	24	22
Stroke . . . "	24.8	26	30	30	27.5
Driving wheel :					
Diameter . . . inches.	78	81	69	63	70.8
Weight of engine . . tons.	91	89.3	181	206	115
Tractive effort . . . lb.	—	33 200	66 000	83 300	—

During 1930, a locomotive having a boiler of this type was built by the North British Locomotive Company, of Glasgow, for the London, Midland and Scottish Railway Company, and later on in the year another of these engines was built by Messrs. Henschel and Sons for the Paris, Lyons and Mediterranean Railway of France. Engines having boilers of this type are at present under construction for the Canadian Pacific Railway and the New York Central Lines. Table 2 gives the leading dimensions, so far as at present available, of locomotives equipped with Schmidt high-pressure boilers.

Winterthur high-pressure locomotive. — The Swiss Locomotive and Machine Company, Winterthur, completed a 2-6-2 tank locomotive about the end of 1927, to the designs of Mr. Buchli, their Chief

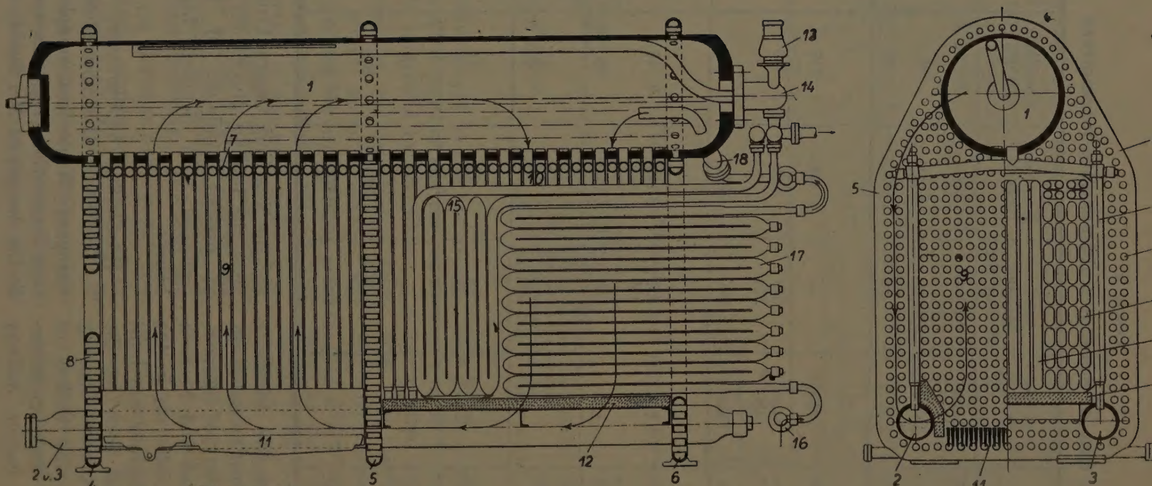


Fig. 6. — Winterthur high-pressure locomotive.

1. Steam-drum.
2, 3. Bottom drums.
4, 5, 6. Waterwalls.
7. Water-tubes
8. Stay-tubes.
9. Firebox.
10. Combustion chamber.
11 Grate.
12. Refractory floor.
13. Safety-valve.
14. Regulator.
15. Superheater.
16, 18. Non-return valves.
17. Main feed-water heater.

Engineer, in which the steam is generated in a boiler of the water-tube type, carrying a working pressure of 850 lb. per sq. inch [1].

The general principle is shown illustrated in figure 5. The boiler is fed by a compound feed-pump, its steam supply passing through a small superheater in the firebox. The feed-water is preheated by exhaust steam to a temperature of about 180° F., and is then pumped through the feed-heater situated in the front of the boiler, where its temperature is raised to about 450° F. The air to the grate passes through a heater situated at the front of the smokebox. The engine is totally enclosed and has three simple cylinders, the cranks being set at 120°. It is fitted with cam-operated poppet-valves, and is of the « Uniflow » type, having exhaust passages at the centres of the cylinders. The single-seated poppet-valves allow of the use of a higher degree of superheat than would be possible with piston-valves, and the high revolution speed and « Uniflow » principle also assist in preventing excessive temperature drop during expansion.

The cam-shaft is operated by means of bevel gearing from the crank-shaft, and different rates of cut-off and reversal are obtained by moving the cam-shaft transversely to bring other cams into engagement. When the locomotive is coasting, the valves can be lifted off their seats to prevent compression. The crank-shaft is geared to the jack-shaft by means of a 2 1/2 to 1 flexible reduction gear. The rods transmitting power to the coupled wheels are attached to the centres of the leading coupling rods, thus limiting the effect of angularity.

The boiler is illustrated in figure 6. It consists of a top drum which acts as a steam-reservoir, and two small bottom drums. The drums are connected together by the water-space walls. These walls are pierced by a number of short tubes which allow the furnace gases to pass through. The water-tube elements consist of two vertical tubes secured at their lower ends to the two lower drums. Their upper ends are joined by a cross-tube which in turn communicates with the upper drum by means of a T piece. The space between the rear and centre water-walls is fitted with a grate and forms the firebox. The superheater is situated at the rear of the front section and communicates with the header which is on the engine side of the regulator. The main feed-water heater is situated in front of the superheater, and is fitted with end caps to allow of the removal of scale.

Before assembly, the various components of the boiler were subjected to exhaustive experiments in order that adequate factors of safety should be obtained. For example, the water-walls were subjected to a steam pressure of 2 800 lb. per sq. inch. The tube elements were also subjected to rigorous tests, and the complete boiler was used for some time as a stationary boiler so that the various accessories could be experimented with.

A photograph of this locomotive is shown in figure 7, and its main particulars are given below :

Boiler pressure : 850 lb. per sq. inch.
Grate area : 14.4 sq. feet.
Heating surface : 215 sq. feet.
Water capacity of boiler : 594 gallons.
Number of cylinders : 3.
Diameter of cylinders : 8 1/2 inches.
Stroke of piston : 13 3/4 inches.
Ratio of gear-wheel transmission : 1/2.5.
Diameter of driving wheels : 60 inches.

(1) See *Bulletin of the Railway Congress*. January 1929. p. 75.

Fig. 7. — « Winterthur » high-pressure locomotive.

Maximum speed : 50 miles per hour.

Water tank capacity : 1 320 gallons.

Coal tank capacity : 2.7 tons.

Weight of locomotive, empty : 62.8 tons.

Weight of locomotive, in working order : 90.8 tons.

Extensive trials have been made with this locomotive in Switzerland, Austria, and France, and during some recent trials a coal consumption of about 2 1/4 lb. per drawbar horse-power hour has been recorded when delivering 800 horse-power at the drawbar, the corresponding water consumption being slightly under 15 lb. The calorific value of the coal was 13 500 B. T. U. per lb.

During the trials it was found that most of the solid matter contained in the feed-water was deposited in the feed-water heater, but some trouble has been experienced by the formation of scale in the boiler tubes. The makers are taking steps which they expect will prevent this in future. It will be seen from the list of dimensions and from figure 7 that the locomotive is only of small size : with a larger locomotive it is expected that considerably better results could be obtained.

Schwartzkopff-Löffler three-cylinder locomotive. — In April 1930 an engine was completed to the order of the German State Railways by the Berlin Machine Works, formerly known as Messrs. L. Schwartzkopff and Company, constructed to the designs of Dr. Löffler, in which a pressure of 1 700 lb. per sq. inch is used. This engine is a three-cylinder engine having two high-pressure and one low-pressure cylinder.

As will be seen from figure 8, the principle on which the boiler is designed is entirely different from that of any locomotive which has previously been built, and whereas in the Schmidt engine distilled water is used as a medium for transmitting the heat from the fire to the water from which steam is generated, in this case the medium of transfer is steam highly superheated in tubes forming the walls of the firebox. Steam in a saturated condition is drawn from the high-pressure drum by means of a circulating pump and is forced through the superheater tubes referred to above, in which it becomes superheated to a temperature of about 900° F., and the pressure raised to approximately 1 700 lb. per sq. inch. About one-quarter of this steam is used for supplying the high-pressure

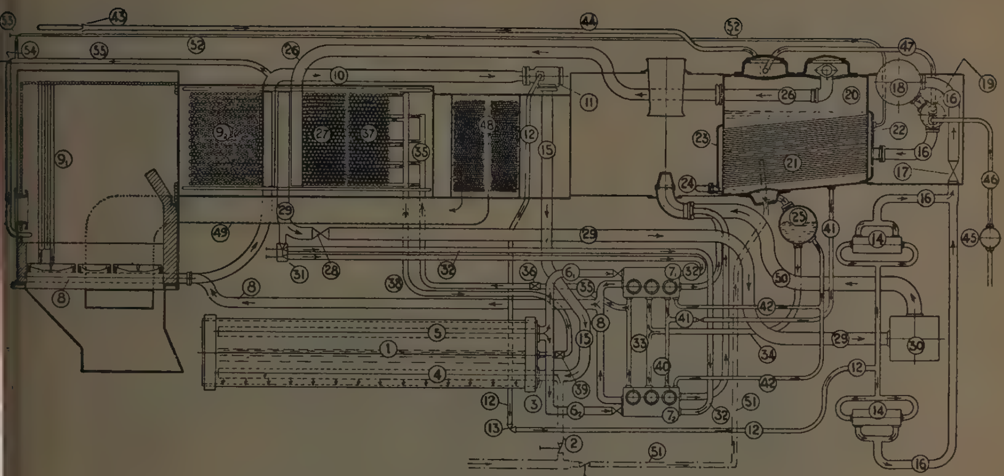


Fig. 8. — Schwartzkopff-Löffler three-cylinder engine.

1. High pressure drum.
2, 3, 51. External steam supply.
4, 5. Delivery and outlet pipes.
6_1, 6_2. Pipes to circulating pumps.
7_1, 7_2. Circulating and feed pumps.
8. Delivery to H.P. superheater.
9_1, 9_2. H.P. superheater.
0, 12. H.P. steam-pipe.
1. Non-return valve, steam.
3. H.P. regulator.
4. H.P. cylinders.
5. Return pipe to H.P. drum.

16. H.P. exhaust pipe.
17. Safety-valve.
18. Oil separator.
19. L.P. feed-water preheater.
20, 21, 22, 23. Low-pressure boiler.
25. H.P. feed-water tank.
26, 29. L.P. steam-pipe.
27. L.P. superheater.
28. L.P. regulator.
30. L.P. cylinder.
31, 32. Valves and steam-pipes for driving pumps.

33, 34, 35, 38. Feed-water pipes for H.P. drum.
36, 39. Non-return valves, water.
37. H.P. Feed-water heater.
40, 41, 42. Supplementary H.P. feedwater system.
43, 45. Injector and feed-pump to L.P. boiler.
44, 46, 47. Feed-delivery pipes, L.P. boiler.
48, 49. Air-preheater and duct to ashpan.
50. L.P. exhaust pipe.
52, 53. Supplementary H.P. steam to L.P. boiler.
54, 55. Emergency valve and pipe.

cylinders, and the remaining three-quarters is returned to the high-pressure evaporating drum. This raises the temperature of the water in the drum, and the steam so generated passes again to the circulating pump for superheating as described above. The exhaust steam from the high-pressure cylinders passes first through an oil-separator, then through the feed-water heater from which the low-pressure boiler is supplied, and thence through tubes in the low-pressure boiler, in which pressure up to about 225 lb. per sq. inch is generated. The condensate from the high-pressure exhaust passes to a feed-water tank whence it is pumped back to the high-pressure drum through the high-pressure feed-water heater, any leakage in steam in the high-pressure system being made up from the low-pressure boiler. Steam generated in the low pressure boiler passes through another superheater in which it is raised to a temperature of about 640° F., from whence it passes to the central low-pressure cylinder, and is finally exhausted up the blast-pipe.

In addition to supplying the low-pressure cylinder, the low-pressure boiler supplies steam for operating all the pumps.

The pumps are in duplicate, a set being situated on each side of the engine. Each set consists of three pumps :

1. the circulating pump for circulating steam from the high-pressure evaporative drum through the superheating tubes forming the firebox;

2. the pump feeding the high-pressure evaporative drum with the condensate from the high-pressure exhaust; and

3. the pump feeding the evaporative drum with the make-up water from the low-pressure boiler. Each of the pumps is capable of delivering about 75 % of the maximum requirements of the boiler, and absorbs about 4 % of the power developed. In order to improve the efficiency of the engine, the air supply to the firebox is preheated to a temperature of 300° F.

From an examination of figure 8 it will be seen that the heat generated in

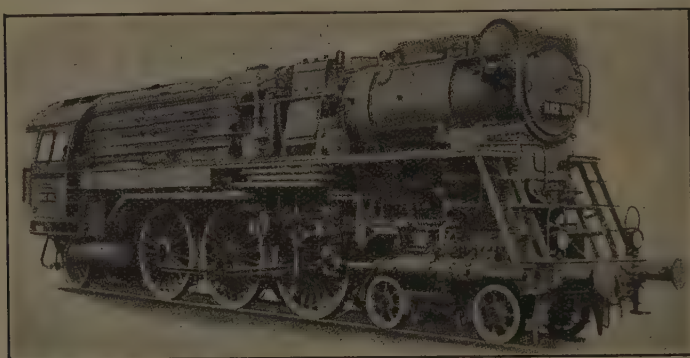


Fig. 9. — Schwartzkoff-Löffler three-cylinder engine.

the firebox is utilized first of all to superheat the steam for the high-pressure cylinder and the evaporative drum. The gases then pass through a nest of tubes raising the temperature of the steam supplied to the low-pressure cylinder, thence through the high-pressure feed-water heater, after that the air-preheater, finally passing up the chimney.

The two outside high-pressure cylinders are machined from steel forgings carried in cast-steel brackets bolted to the frame. They are free to expand in this bracket in a longitudinal direction to avoid stresses. Owing to the small size of the cylinders, tail-rods have had to be provided to equalize the power on the forward and backward strokes. Steam is distributed to the cylinders by piston-valves and in all other respects the construction of the motion, frames, etc., is similar to that employed by the German State Railways.

The Author has described only the main principles of the Löffler locomotive, but whilst no doubt every effort has been made to utilize as far as possible the heat generated in the firebox, it must be admitted that this has only been effected by a very intricate and complicated system of tubes and drums. It will be appreciated also that the design involves

the use of a very large number of joints and connexions, a failure of any one of which might have serious results. Another serious drawback to this locomotive is that steam can only be raised if a steam supply from another source is available for the initial heating up of the water in the high- and low-pressure steam generators. The pressure in the latter must rise to about 70 lb. per sq. inch before the pumps can be started, and until then the fire cannot be lit in the grate. It is usually convenient to obtain this steam from another locomotive. The most important feature, however, in connexion with the working of the engine, is the necessity for absolute reliability in the circulating and feed-pumps, and this no doubt is the reason why the designer has thought fit to duplicate this feature in the engine.

In the Löffler boiler there is no necessity to use distilled water, ordinary feed-water being quite satisfactory because the concentration and deposit of scale is only possible in the high-pressure evaporative drum which is not heated by either fire or high-temperature circulating tubes as in the case of the Schmidt boiler. Boiler scale will therefore have no injurious effect.

Special precautions have been taken to ensure safety as far as possible. Non-return valves are situated in the high-pressure steam and feed-water pipes so that in the event of a superheater pipe bursting, the high-pressure drum is isolated, and only the steam in the superheater can escape. Safety devices have also been incorporated for rapidly reducing the firebox temperature in case of pump failure.

It is claimed that with this locomotive a fuel economy of 45 % will be attained and its overall thermal efficiency will be raised to nearly 18 %. It is difficult to reconcile these claims, as an efficiency of 18 % is more than double that of an ordinary locomotive. Trial runs have been made with this locomotive but the Author has not been supplied with the actual results obtained. A photograph of this locomotive is given in figure 9, and its main dimensions are given below :

Grate area : 26 sq. feet.

Heating surfaces :

High-pressure superheater: 970 sq. feet.
Low-pressure superheater : 344 sq. feet.
High-pressure preheater : 764 sq. feet.
Low-pressure boiler : 882 sq. feet.

Boiler pressures :

High-pressure boiler : 1 700 lb. per sq. inch.

Low-pressure boiler : 215 lb. per sq. inch.

Motion :

Diameter of high-pressure cylinders : 8 5/8 inches.

Stroke of high-pressure cylinders : 26 inches.

Diameter of low-pressure cylinder : 23 5/8 inches.

Stroke of low-pressure cylinder : 26 inches.

Diameter of driving wheels : 78 3/4 inches.

Diameter of bogie wheels : 33 1/2 inches.

Diameter of trailing wheels : 49 1/4 inches.

Weight empty (calculated): 110 tons.

Weight in working order (calculated): 113 tons.

Adhesive weight : 59 tons.

Four-cylinder high-pressure compound locomotive, London and North Eastern Railway. — The first British high-pressure locomotive to be built is the four-

Fig. 10. — Four-cylinder high-pressure compound locomotive, London and North Eastern Railway.

LEADING DIMENSIONS AND RATIOS.

Grate.	
Length on slope	7 ft. 6 in.
Width	4 ft. 8 in.
Grate area	34.95 sq. feet.
Boiler.	
Steam-drum :	
Length	27 ft. 11 5/8 in.
Diam. inside	3 ft. 0 in.
Water drums, forward :	
Length	13 ft. 5 3/4 in.
Diam. inside	1 ft. 7 in.
Water drums, back :	
Length	11 ft. 0 5/8 in.
Diam. inside	1 ft. 6 in.
Smokebox length	16 ft. 1 in.
Working pressure	450 lb. per sq. inch.
Tubes.	
Small :	
Number	444
Diam. outside	2 in.
Combustion chamber :	
Number	74
Diam. outside	2 1/2 in.
Firebox :	
Number	250
Diam. outside	2 1/2 in.
Heating surface.	
Firebox	919 sq. feet.
Combustion chamber	195 —
Small tubes	872 —
Total evaporative	1 986 —
Superheater.	
Number of elements	12
Diam. inside	1.18 in.
Heating surface	140 sq. feet.
Total heating surface	2 126 —
Axles.	
Journals :	
Bogie	6 1/2 in. × 11 in.
Coupled wheels	9 1/2 in. × 11 in.
Carrying —	6 in. × 11 in.
Bissel —	6 1/2 in. × 11 in.
Crank-pins.	
Outside	5 1/2 in. × 6 in.
Inside	8 1/4 in. × 5 3/4 in.

Coupling pins.	
Leading	4 in. × 4 3/8 in.
Driving	6 in. × 4 1/4 in.
Trailing	4 in. × 4 1/2 in.
Springs.	
Bogie wheels :	
Type	Laminated.
Length	2 ft. 6 in. centres.
Number of plates	8
Size of plates	4 1/2 in. wide × 7/16 in.
Coupled wheels :	
Type	Laminated.
Length	3 ft. 6 in. centres.
Number of plates	11
Size of plates	5 in. wide × 5/8 in.
Carrying wheels :	
Type	Laminated.
Length	4 ft. 6 in. centres.
Number of plates	10
Size of plates	5 in. wide × 5/8 in.
Bissel :	
Type	Helical.
Outside diam.	5 1/2 in.
Free length	10 3/16 in.
Cylinders.	
High-pressure	(2) 10 in. × 26 in.
Low-pressure	(2) 20 in. × 26 in.
Motion.	
Type	Gresley-Walschaerts.
Valves :	
Type	Piston.
Diam. H. P.	6 in.
Diam. L. P.	8 in.
Max. travel, H. P.	8 9/16 in.
Max. travel, L. P.	6 11/16 in.
Steam lap, H. P.	1 3/8 in.
Steam lap, L. P.	1 5/8 in.
Exhaust lap	nil.
Cut-off in full gear, H. P.	90 %.
Cut-off in full gear, L. P.	75 %.
Tractive effort	32 000 lb.
Total adhesive weight	140 000 lb.
Adhesive weight: tractive effort	4.37
Brakes	Steam brake and vacuum ejector.

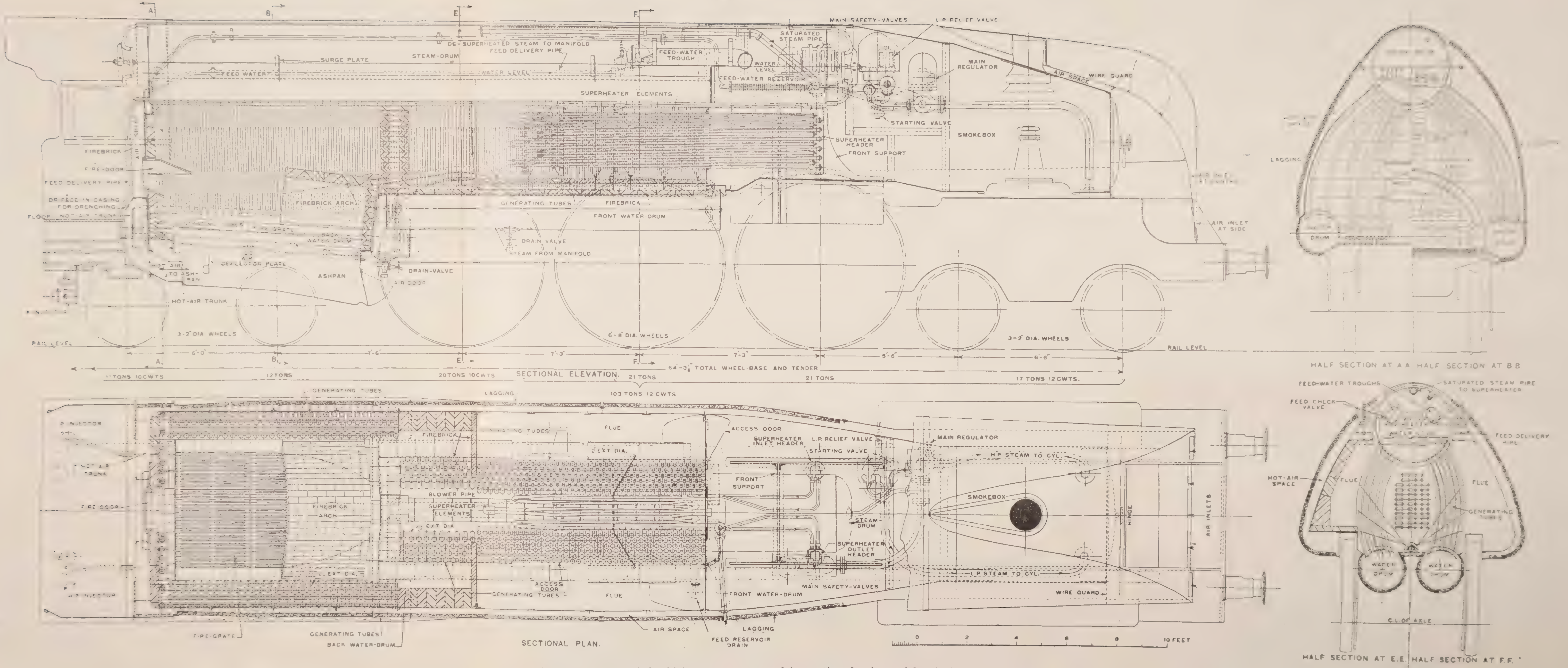


Fig. 10. — Four-cylinder high-pressure compound locomotive, London and North Eastern Railway.

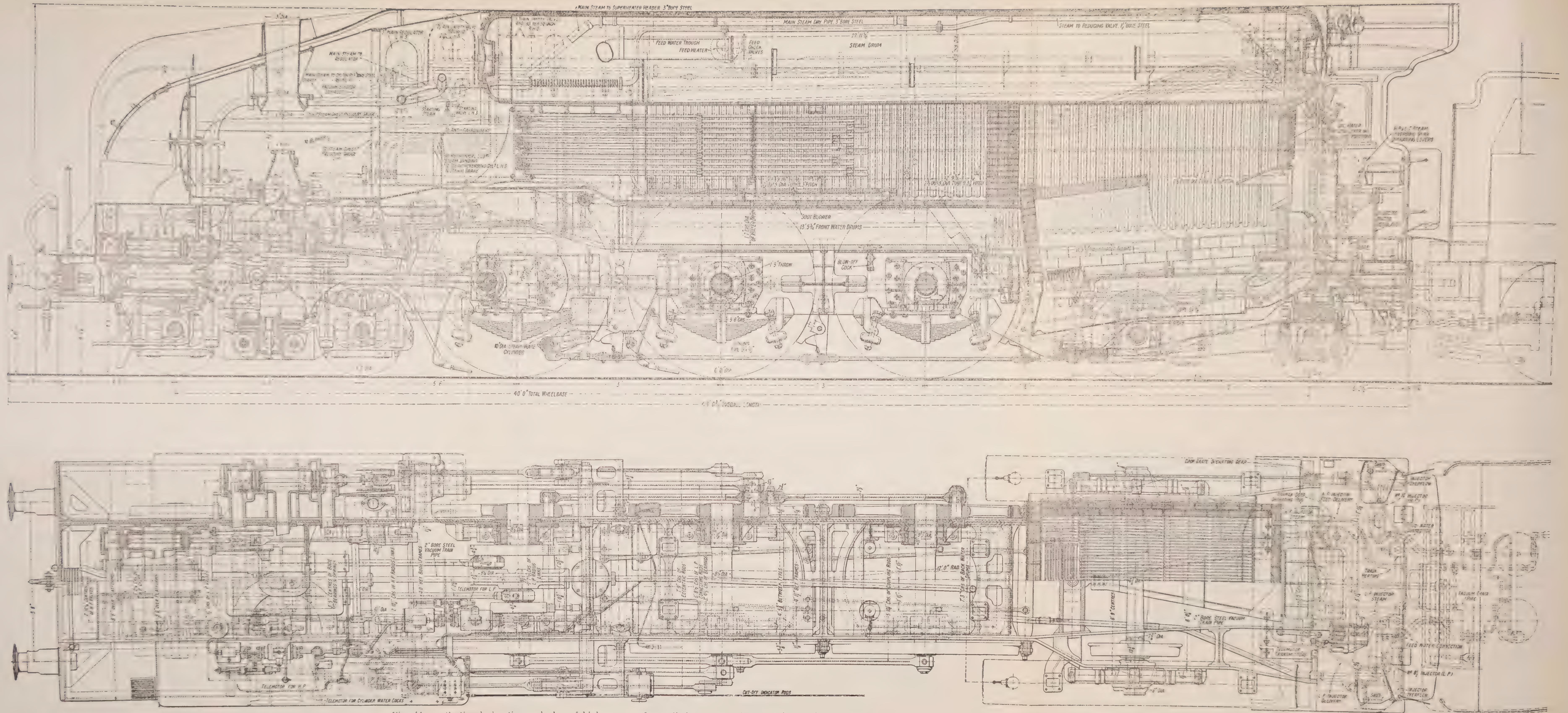


Fig. 11. — Sectional elevation and plan of high-pressure four-cylinder compound express locomotive, with Yarrow-Gresley water tube boiler, London & North Eastern Railway.

(Reproduced from *The Railway Engineer*.)

cylinder compound engine of the London and North Eastern Railway, which was completed at the end of 1929. Unlike his Continental colleagues, the Author, in designing this engine, thought it advisable to be content with what may be regarded as only a moderate increase in boiler pressure to 450 lb. per sq. inch. In coming to this decision he was largely influenced by consideration of maintenance costs and the desirability of advancing by stages. Past experience of revolutionary designs has been that the spectacular advancements have not always been justified by results, and consequently the Author deemed it wiser to seek progress on a less ambitious scale. He also recognized that as the pressure increases the economies to be expected in fuel consumption are in a diminishing ratio.

He decided to adopt a boiler of the water-tube type, in view of the successful application of such boilers to high pressures in marine practice and in large power stations. In September 1924 he accordingly approached Mr. Harold Yarrow, of Glasgow, whose firm are so well known as designers and builders of water-tube boilers, and suggested to him a design of boiler of the water-tube type which might be applied to locomotives. A water-tube boiler suitable for a locomotive involves a radical departure from the usual design of such boilers for marine and land purposes, and upwards of three years of work on the part of Mr. Yarrow and the Author resulted in the completion towards the end of 1927 of the final design, which was patented in their joint names. Early in 1928 an order was placed with Messrs. Yarrow to proceed with the construction of the boiler, which was completed and tested in October 1929. The engine was built at the Darlington Works of the London & North Eastern Railway, and ran its trial trip on 12 December 1929.

The drums of the boiler are of sufficient diameter to allow a man to get inside them for the purpose of expanding the tubes. To suit the conditions peculiar to a locomotive, it was felt that tubes of a large diameter only should be used, the tubes in the firebox end of the boiler being 2 1/2 inches external diameter and the tubes in the forward part 2 inches. Figure 10 gives a sectional elevation and cross-section of the boiler and shows its general form of construction. The considerations which govern the design of marine and land boilers are so entirely different from those required in a locomotive boiler, that there is very little similarity between the boiler used on this engine and the ordinary type of water-tube boiler, as will be seen from the photograph, figure 12.

In the ordinary water-tube boiler resting on foundations, the boiler can expand freely in any direction, and the tubes, not being subjected to vibration and racking stresses, are not liable to leak. In a locomotive, the boiler must be so secured to the frame that in addition to standing the shocks and vibrations consequent upon the engine running at high speed upon a railway, it must be capable of withstanding the shocks which occur when a locomotive is shunting, or comes in contact with buffer stops, or possibly becomes derailed.

It is necessary also to have due regard to the fact that the boiler provides an important structural element in the construction of a locomotive and contributes to its rigidity. It will be seen from the diagram that in this boiler the large steam-drum forms the backbone of the boiler, from which the tubes and the small drums depend. At the forward end

Fig. 12. — Boiler.

this drum is carried in a cast-steel cradle into which it is firmly secured by large strap bolts, and any fore-and-aft movement is entirely prevented by stops which are machined on the lower side of the drum. The cradle in turn is secured to the engine frame by 1-inch steel plates extending downwards inside the main engine frames, to which they are securely riveted. The steel drum must be free to expand longitudinally, and accordingly the back end is secured to the top of a triangular-shaped transverse plate which in turn is secured at its lower extremity to the engine frame. The drum therefore, whilst being free to expand longitudinally, is constrained from side or vertical motion.

The four smaller drums are not supported, but hang from the water-tubes. Rectangular lugs are riveted to the lower side of each of these drums at their forward and back ends. These rectangular lugs are free to slide longitudinally

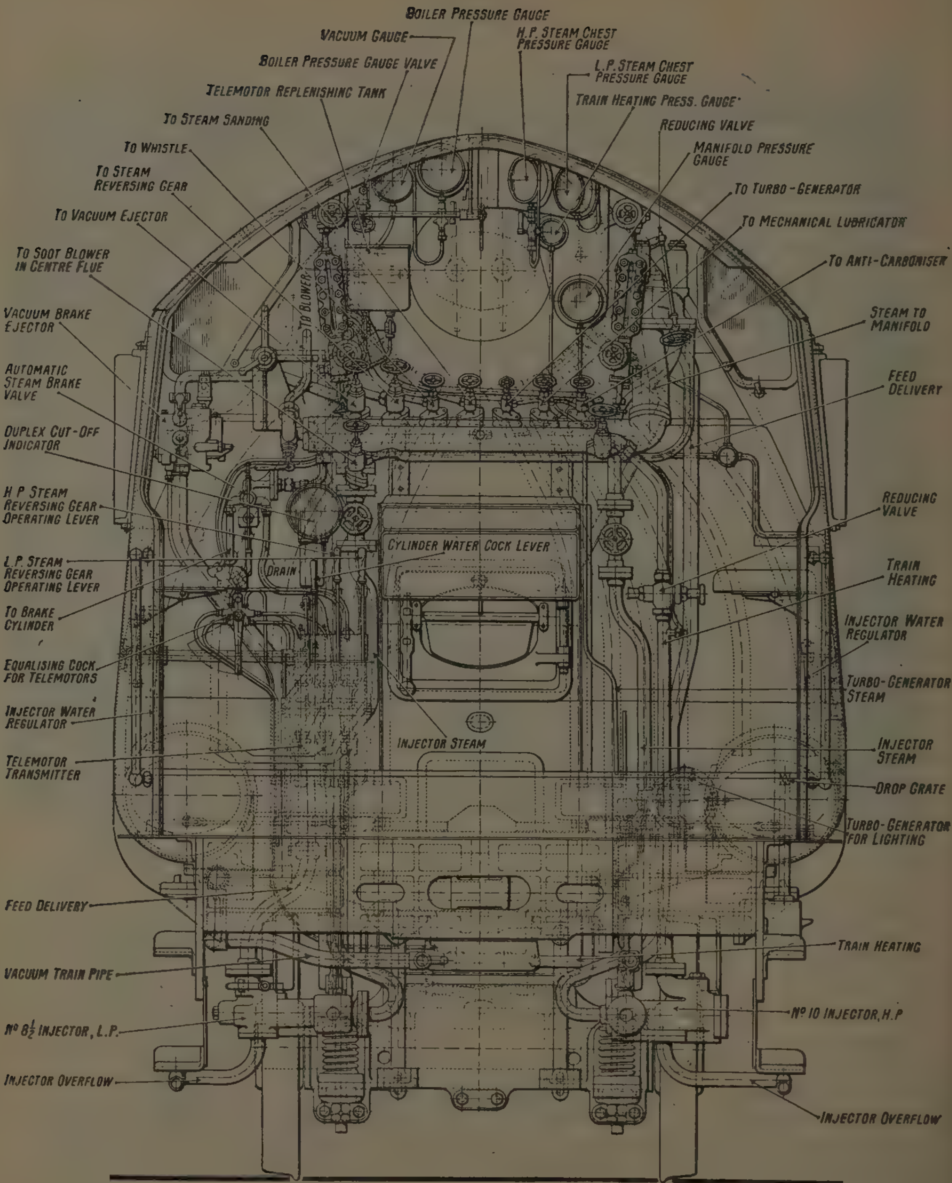
in grooved castings which are secured to the engine frame, but as they do not reach the bottom of the grooves, they are also free to move vertically. These lugs and grooves are provided to restrain the drums from any side movement. It was considered that this was the best way of preventing the transmission of vibration and shocks to the tubes in such a way as might cause leakage. It is interesting to note that this method of construction has been completely successful, in that there has been no case of the slightest leakage occurring at any of the 1 536 points at which the tubes have been expanded in the drums.

In adopting a water-tube boiler, the Author was not unmindful of the troubles which might reasonably be expected to result from scale formation in the tubes. Unlike marine and power-house boilers, in which the boiler feed is derived from the condensate and only a very small make-up of fresh water is required, the locomotive boiler requires 100 % of make-up water. In order to prevent the formation of scale as far as possible, the Author decided to introduce the feed-water at the highest possible temperature. It will be seen from the diagram that the feed-water is introduced into a chamber at the forward end of the top drum in front of the water-tubes and separated from the evaporative portion of the boiler by a weir at a height of about half its diameter.

The water is supplied from the tender by means of two ordinary injectors, and is delivered into this forward space of the top drum, after passing through a form of injector heater. The latter has two sets of cones in which the injector action is repeated by steam from the steam space in the boiler. Heat is absorbed to such an extent by the feed-water that its temperature when delivered into the water chamber is over 400° F. and is therefore only about 50° less than that of the saturated steam in the boiler. Much of the scale and mud is consequently thrown down in the forward portion of the top drum.

But for this arrangement for dealing with the feed-water, considerable trouble due to the formation of scale would have to be expected; as it is, after running some 15 000 miles, a slight deposit of hard scale was found on the inner rows of tubes in the firebox. This was at first not easy to detect, and in consequence about half-a-dozen tubes on each side of the firebox adjacent to the brick arch showed signs of overheating and had to be changed. The experience gained has resulted in the development of an apparatus by which the hardest scale can be readily cut out without damage to the tubes, and this will probably be necessary when the engine has run some 10 000 to 15 000 miles, according to the class of feed-water used.

On the other hand, experience has also shown that this boiler can be worked for a much longer period than the ordinary type of locomotive boiler before requiring to be washed out. When stationed at Gateshead the locomotive worked express trains from York to Edinburgh and back, involving a daily run of about 420 miles. Whilst other engines of the *Pacific* type in the same « link » require washing out after running 1 000 to 1 500 miles, this engine ran 5 000 miles without washing out, and when opened up it was found that the boiler was exceptionally clean and the tubes were in good condition. It was, however, found that the accumulation of mud and scale, which usually occurs above the foundation ring in an ordinary boiler, had fallen into the drums



(Reproduced from *The Railway Engineer.*)

Fig 13. — End elevation of footplate, showing fittings.

below the grate on each side of the firebox. This material remained in the drums in the form of mud, from which it was easily removed, whereas if it had been in the sides of an ordinary locomotive firebox, much of it would have formed into scale.

Other means, which will be described later, have been recently embodied, by which the temperature of the water when delivered in the feed-water space in the top drum is further increased before it passes to the evaporative portion of the boiler.

In a test which was carried out at the makers' works, an evaporation of 20 000 lb. per hour at 450 lb. per sq. inch was maintained for a period of four hours by the introduction of a steam jet up the chimney. This high rate of evaporation is possible owing to such a large proportion of the heating surface available being subject to direct radiant heat. In the ordinary form of locomotive boiler only the firebox is subject to radiant heat, and the evaporation per square foot of heating surface of the tubes is only about one fifth of that of the firebox sides.

The superheater elements in this boiler are located in the forward portion of the central flue and are also subject to radiant heat. In order to prevent the flame impinging directly on the ends of the elements, a brick column is provided in the centre of the main flue immediately in front of the brick arch. Notwithstanding this precaution, and owing to the fact that there were no data available as to the effect of radiant heat on superheater elements, the temperature to which the steam was superheated during the preliminary trials was excessive, temperatures of 900° F. being obtained; consequently the lengths and area of the superheater elements have been reduced so

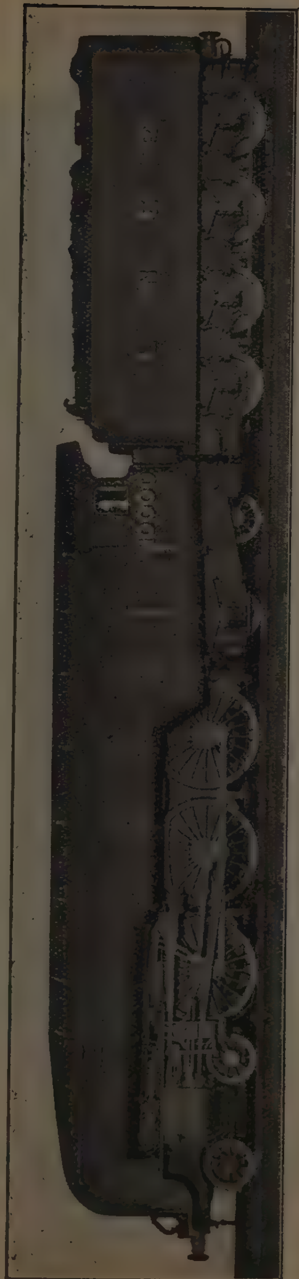


Fig. 14. — Four-cylinder high-pressure locomotive, London and North Eastern Railway.

that a temperature of approximately 700° F. can now be obtained, and this is regarded as sufficient. The superheater elements are situated between the boiler and the regulator and are, therefore, always subject to full boiler pressure. In order to prevent overheating when the regulator is closed, the steam supplied for auxiliary services is taken from the superheater and passes through a coil of ribbed pipes laid in the feed-water chamber, thus raising further the temperature of the boiler feed and at the same time de-superheating the steam. This de-superheated steam is led to the reducing valve where its pressure is reduced to 200 lb. per sq. inch. Steam from this reducing valve supplies a manifold pipe on the footplate across the front of the boiler above the firehole door. From this manifold pipe steam at 200 lb. per sq. inch pressure is taken for supplying all the auxiliary services, such as the injector, vacuum and steam brake, reversing gear, steam-sanding, steam-heating, whistle, and turbo-generator. It has been possible to retain the standard steam fittings for all these purposes. Figure 13 shows the end elevation of the footplate and the arrangement of the fittings.

With a pressure of even 450 lb. per sq. inch special designs of boiler fittings and valves have to be used owing to the cutting action of high-pressure steam, but in this engine only the safety-valves, regulators, H. P. injector and water-gaúges have had to be made suitable for this pressure.

After the hot gases have passed between the water-tubes they enter the flues located at each side of the boiler. Naturally the walls of these flues are very hot, and in order to reduce their temperature and to make effective use of this heat, which otherwise would be wasted, the boiler is surrounded by an air space lying between the casing of the flues and the insulated outer clothing. All the air required for combustion traverses this air space from the intake at the front of the engine to the ashpan, and in so doing its temperature is raised to about 250° F. It has been found that even when working hard it has not been necessary to supplement this supply of hot air by opening the ashpan door. Preheating the whole of the air supply is bound to augment the thermal efficiency of the boiler.

The only other feature of the boiler which calls for comment is the construction of the front end and chimney. Incidentally, the apparent absence of the chimney has caused more public comment than any other feature of the locomotive. (Side and front views are shown in figures 14 and 15). In order to provide sufficient length for the water-tubes, it was necessary to have the top steam-drum as high as the limits imposed by the load gauge permit, consequently there was no room for a chimney of the conventional type. Engines having large high-pitched boilers can only have very short chimneys, and trouble has been experienced in such engines owing to smoke and steam beating down on the front windows of the cab and interfering with the driver's view of signals. The Author enlisted the assistance of Professor W. E. Dalby and constructed a wooden model of an engine of such a type. This model was placed in an air flume, and powdered chalk was blown up the chimney at the same time as a current of air was drawn through the flume at 30 m.p.h. Observations through a glass window showed the course pursued by the powdered chalk, and as a result of various modifications, the design finally adopted was arrived at. In this design the whole of

Fig. 15. — Front view of engine.

the powdered chalk was lifted sufficiently to clear the cab windows, and it is satisfactory to record that in actual service the smoke and steam, whether running at slow or at high speeds, is deflected upwards sufficiently to clear the

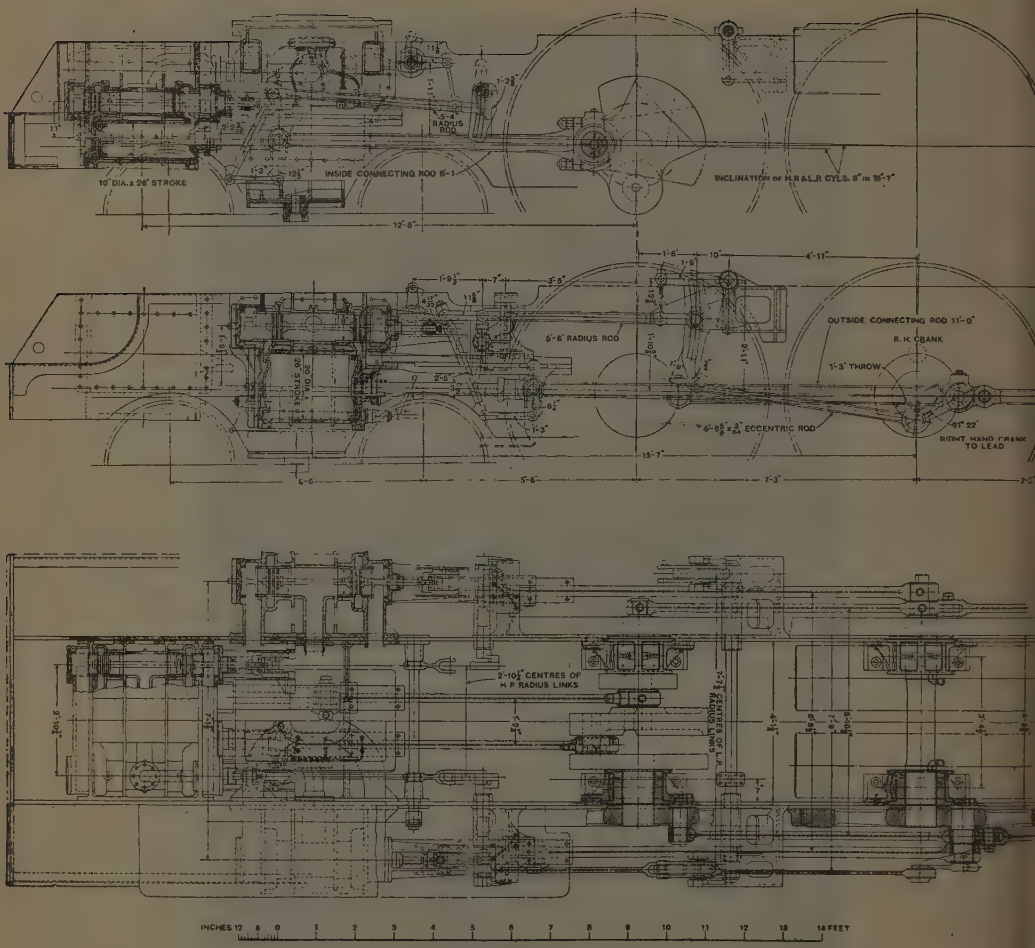
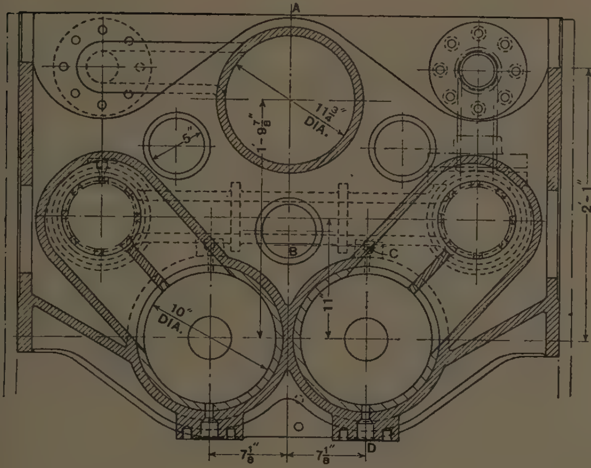


Fig. 16. — Motion arrangement.

cab, and in no way obstructs the driver's vision.

As originally built the engine had two high-pressure cylinders 12 inches in diameter, and two low-pressure cylinders each 20 inches in diameter, all cylinders having 26 inches stroke. It has been found that by reducing the diameter of the high-pressure cylinders to 10 inches a more equal distribution of work be-

Section through E. F.



Section through A. B. C. D.

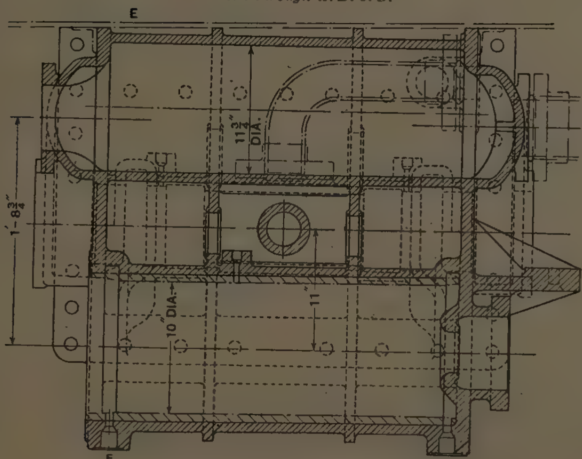


Fig. 17. — High-pressure cylinders.

10 inches diameter; 26 inches stroke.

tween the high-pressure and low-pressure cylinders results.

The Author regarded it as necessary, whilst having only two sets of valve-gear, to be able to vary the cut-off of the high-pressure cylinder independently of that of the low-pressure cylinder. He felt that only by trial at varying cut-offs could the best results be realized. He therefore arranged that in the rocking link by which the high-pressure valve is actuated, provision should be made by means of a slot and die-block to vary the travel of the valve, at the same time retaining the combination lever to keep the lead constant. The motion arrangement for both high- and low-pressure cylinders is shown in figure 16. The reversal of the low-pressure valve-gear, and consequently of the whole engine, is actuated by the ordinary form of steam-reverser, and a similar equipment is provided to vary the high-pressure cut-off. Both these equipments are attached to the shafts they actuate, and being so remote from the footplate, their delicate control was not easy. This has been successfully effected by the use of telemotors; another telemotor is also provided for operating cylinder cocks. The high-pressure cylinders, steam-ports, passages, and low-pressure steam-receiver are formed by a single steel casting as illustrated in figure 17, the cylinders and steam-chests having special close-grained cast-iron liners.

Various minor alterations and adjustments have had to be made since the engine was built, but with the exception of reducing the diameter of the high-pressure cylinders and reducing the heating surface of the superheater, it has not been necessary to alter any of its main features.

The locomotive has worked trains of over 500 tons' weight for long distances at express speeds with consistent success and reliability, and although it has not been possible so far to carry out any extensive trials, there is every indication that it will prove more economical in fuel consumption than express engines of the latest normal types. Any economy effected in maintenance cost will only become fully apparent after the engine has run a few years.

It has been ascertained that the cost of a water-tube boiler similar to that fitted on this engine will not be appreciably greater than that of the ordinary wide firebox type as fitted on *Pacific* engines. The most expensive components of the water-tube boiler are the solid-forged steam- and water-drums. These are not subjected to the action of the fire, and consequently may be expected to have a long life. On the wide firebox type of ordinary boiler the copper firebox is the most costly section, and it is well known that its life is short and its renewal is an expensive item. Again, in the ordinary type of locomotive boiler tubes and firebox stays are sources of trouble involving costly maintenance and occasional failures. In the design of boiler under consideration there are no stays; the tubes are more effectively secured, and are not subjected to variation in temperature and stress at the points where they enter the drums.

In conclusion, the Author submits that, with the moderately high pressure and simple design which he has adopted, economy both in fuel and maintenance costs will be secured and at the same time the reliability so characteristic of British locomotives will be fully maintained.

[621. 132.3 (.493)]

Type 5 " Mikado " locomotives of the Belgian Railways (1),

by F. LEGEIN,

Chief Engineer, Locomotive and Rolling Stock Department of the Belgian National Railway Company.

Fig. 1 to 5, pp. 408 to 419.

The Belgian National Railway Company has just put into service a new type of locomotive, classed as type 5, for working the international trains on the Brussels-Arlon line (fig. 1).

As is known, this line forms the line of communication from Brussels towards Switzerland through Luxemburg and Alsace-Lorraine, and presents considerable traction difficulties; in fact, it consists of a succession of upward and downward grades, frequently of as much as 1 in 62, and of curves of radii as small as 500 m. (25 chains). The most difficult sections of the line are those from Namur to Courrière [12 km. (7. miles) of 1 in 62 rising gradient, with a short stretch of level in the middle] and from Jemelle to Libramont, the highest point of the line [at an altitude of 485 m. (1 590 feet)]. This last section, of a length of 32 km. (20 miles), consists of a continuous up-gradient with frequent curves and reverse curves of 500 m. (25 chains) radius.

Up to the present, the international trains on the Luxemburg line have been worked by « Pacific » locomotives (type 10) with four cylinders, simple expansion, 1.98-m. (6 ft.-6 in.) wheels; and an adhesive weight of 67 t. (65.9 Engl. tons) (2).

The lay-out and the present leading dimensions of this type of locomotive are shown in figure 2.

Although this type of locomotive has undergone important modifications, resulting in an appreciable increase in power, the load of trains which it is able to haul up a gradient of 1 in 62 is limited to 430 t. (423 Engl. tons) owing to its adhesive weight.

For some years this load has been insufficient, the weight of the international trains on the Luxemburg line reaching 600 t. (590 Engl. tons) during two or three months of the summer. Also, everything goes to show that this position will become more pronounced in the future, so that the Belgian National Railway Company has considered it necessary to introduce a type of locomotive capable of hauling with one engine, a train of 600 t. to the present timings of the ordinary international trains on the line.

In order to realise this object, an adhesive weight of 92 t. (90.5 Engl. tons) is necessary and as the Permanent Way Department allows an axle load of 23 t.

(1) Translated from the French.

(2) See *Bulletin of the Railway Congress*, August 1926, p. 663.

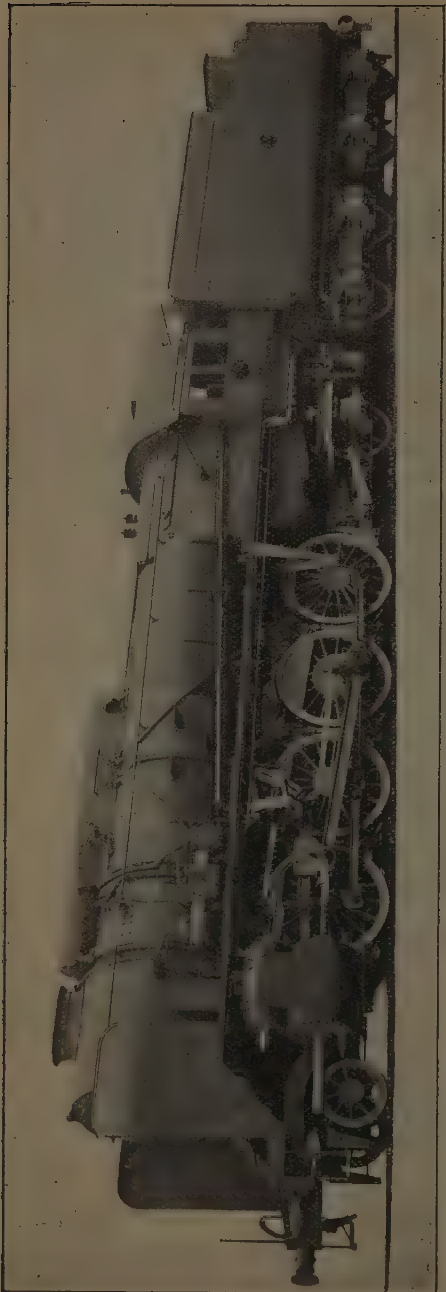


Fig. 1.

(22.6 Engl. tons), the locomotives required need only be eight wheels coupled. Further as the normal running speed was limited to 90 km. (56 miles) per hour, the maximum speed of 100 km. (62 miles) only having to be reached on some sections, the front end of the locomotive could be carried on a two-wheeled truck only. This is why the *Mikado* type was chosen, the use of the trailing carrying wheels being obviously necessary in view of the size of the firebox to be provided.

The diameter of the coupled wheels was fixed at 1.700 m. (5 ft. 7 in.); this diameter is like that of foreign locomotives engaged on analogous services; it is also that of the old Belgian State locomotives specially working the Luxemburg line (loc. types 2, 6, and 16).

Further, this diameter is well chosen because it allows of the maximum speed (90 to 100 km. [56 to 62 miles]) per hour being attained, at the same time keeping a sufficiently high speed of rotation when working up heavy gradients.

In view of being able to allow a fairly high load on the trailing pair of wheels, and of using 6-m. (19 ft.-8 in.) tubes, it was possible to avoid using a combustion chamber with the construction and maintenance difficulties this arrangement entails.

The new locomotive has two simple-expansion cylinders. This arrangement is preferred to any other, with three or four cylinders, owing to its great simplicity, to the ready accessibility of all parts of the mechanism, and to the reduction of the cost of both construction and maintenance.

Experience has also proved that simple expansion engines have considerable advantages over compounds, when used over heavily graded lines, over which heavy

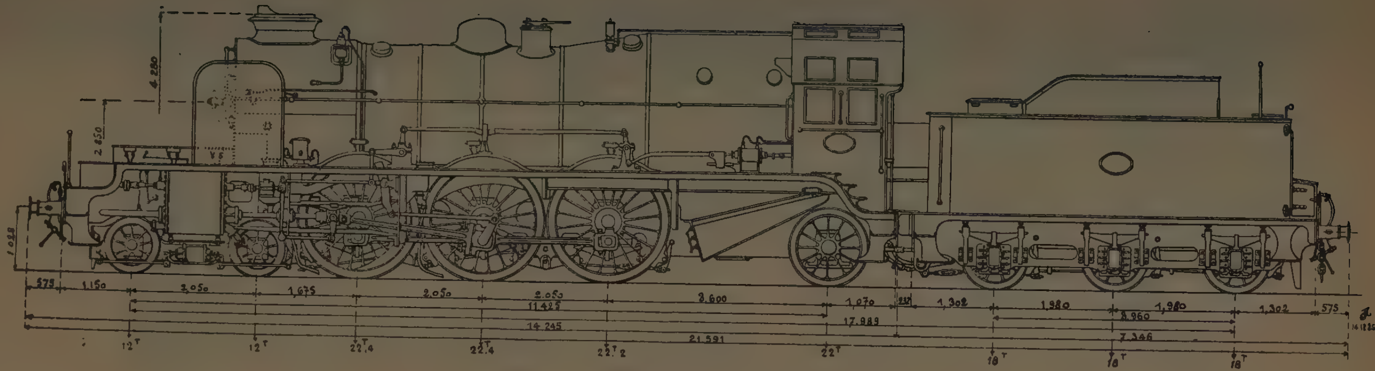


Fig. 2. — Modified type 10 express locomotive.

Leading dimensions.

Number of cylinders.	4
Diameter of the cylinders	500 mm. (19 11/16 in.).
Stroke	660 mm. (26 in.).
Boiler working pressure	14 kgr./cm² (199.1 lb. per sq. inch).
Diameter of driving wheels	1 980 mm. (6 ft. 6 in.).
— leading truck wheels . .	900 mm. (2 ft. 11 1/2 in.).
— trailing wheels	1 262 mm. (4 ft. 1 5/8 in.).
Grate area	5.00 m² (53.8 sq. feet).
Number of tubes 45/50 (1 $\frac{49}{64}$ in. / 1 $\frac{31}{32}$ in.)	190

Number of flues 125/133 (4 $\frac{25}{64}$ in. / 5 $\frac{15}{64}$ in.)	40
Length of tubes between tube plates	5.000 m. (16 ft. 5 in.).
Mean internal diameter of boiler barrel. . . .	1.800 m. (5 ft. 10 7/8 in.).
Heating surface — firebox	19.91 m² (214.3 sq. feet).
Heating surface — tubes	212.78 m² (2 290.4 sq. feet).
Heating surface — total	232.69 m² (2 504.7 sq. feet).
Superheating surface.	75.79 m² (815.8 sq. feet).
Total weight in working order.	113 t. (111.2 Engl. tons).
Adhesive weight	67 t. (65.9 Engl. tons).

work has to be done, and where the use of late cut-offs are customary.

The method of construction of the cylinders, the motion, the frame, and the springing closely conforms to United States practice. The main frames are of the « bar » type, and the cylinders are secured to them on the horizontal centre line and are arranged to carry the smokebox.

Finally, it has been deemed advantageous to make the engine higher than has been usual during recent years on the Belgian State Railways.

The new locomotive is 4.48 m. (14 ft. 3 1/8 in.) high above the rails, which the standard Belgian gauge allows.

On the other hand, the lower parts have been designed to clear a tighter gauge than the standard, in order to make possible, in the future, the installation of new permanent way or signalling apparatus.

The designs of this locomotive type 5, were made by the « Société Anonyme Les Ateliers Métallurgiques » at Tubize, in close collaboration with the Headquarters of the Belgian National Railway Company's Locomotive and Rolling Stock Department.

The diagram, figure 3, illustrates the general arrangement of the engine, and gives its leading dimensions.

Detailed description.

Boiler. — The boiler pressure is 14 kgr. (199.1 lb. per sq. inch).

The centre line of the boiler shell is 3 m. (9 ft. 10 1/8 in.) above rail level; it consists of three telescopic rings, the plates being 19.5 mm. (49/64 inch) in thickness, the maximum internal diameter being 2 m. (6 ft. 6 3/4 in.).

These rings are made of steel of a minimum tensile strength of 40 kgr./mm² (25.4 Engl. tons per sq. inch) with a minimum elongation of 27 %.

The fire-box is deep, and extends over the main side frames. The grate has a length of 2.50 m. (8 ft. 2 1/2 in.) and a width of 2.20 m. (7 ft. 2 5/8 in.) giving an area of 5.50 m² (59.2 sq. feet).

Although a surface of 4.85 m² (52.2 sq. feet) would have been sufficient, it was thought useful to increase it up to 5.50 m² so as not to be always obliged to use fuel of the very best quality.

The grate is of the « shaking » type, with a drop-grate at the front end, worked by a hand-lever.

The inside firebox, of copper, is of the ordinary type, without a combustion chamber. The top of the firebox is given a slope of 19 mm. per metre (1 in 56) towards the back, the locomotive being intended to work over undulating track.

The arch is formed of bricks simply carried on four mild steel 67/76-mm. (2 41/64-inch—3-inch) water tubes.

As regards the tubes there are 170—50/55-mm. (1 31/32-inch—2 11/64-inch) tubes, and 43—128/137-mm. (5-inch—5 25/64-inch) flues containing the superheater elements. The distance between the tube plates is 6 m. (19 ft. 8 1/4 in.).

The box is fired through two doors of the standard type, with horizontal hinges, of the automatic closing type.

The boiler is fitted with two water-level indicators, of the Dewrance type, two fusible plugs, and two Coale safety valves, 89 mm. (3 1/2 inches) in diameter.

The boiler feed-water is normally delivered on the left hand side (the driver's side), by an A. C. F. I. type R. M. feed-water heater of an hourly capacity of 21 687 litres (4 770 British gallons).

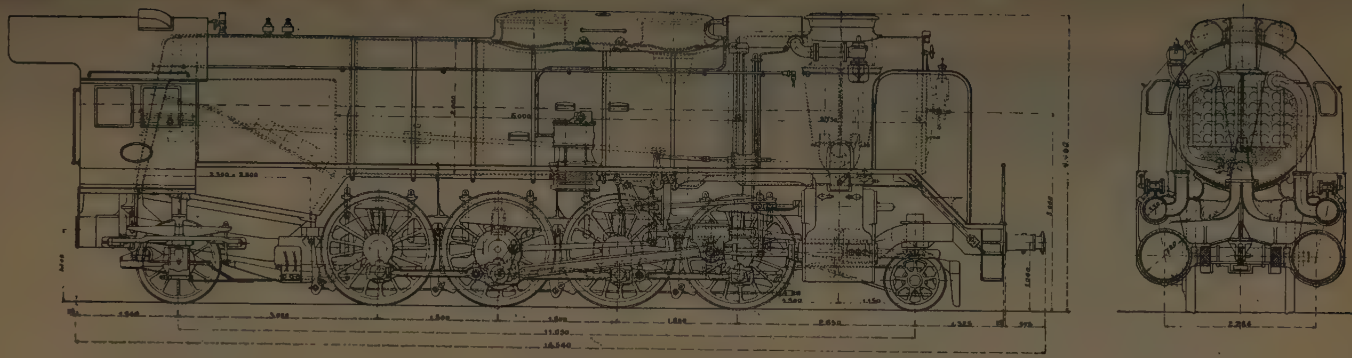


Fig. 3. — Locomotive type 5.

Leading dimensions.

« MIKADO » TYPE LOCOMOTIVE. 2-8-2

Motion.	2 cylinders	Diameter (d)	720 mm. (28 3/8 in.).
		Stroke (l)	720 mm. (28 3/8 in.).
	Diameter of driving wheels		1 700 mm. (5 ft. 7 in.).
	— leading carrying wheels (D)		900 mm. (2 ft. 11 1/2 in.).
	— trailing carrying wheels		1 262 mm. (4 ft. 1 5/6 in.).
Boiler.	Pressure (p)		14 kgr./cm² (119.1 lb. per sq. inch).
	Grate	length	2.500 m. (8 ft. 2 1/2 in.).
		width	2.200 m. (7 ft. 2 5/8 in.).
		area	5.50 m² (59.2 sq. feet).
	Distance between tube plates		6.000 m. (19 ft. 8 in.).
	Tubes 170, diameter		50/55 mm. (1 31/32 in. — 2 11/64 in.).
	Flues 43, —		128/137 mm. (5 in. — 5 25/64 in.).
	4 arched water tubes		67/76 mm. (2 41/64 in. — 5 25/64 in.).
	Superheater units		30.5/38 mm. (1 7/32 in. — 1 1/2 in.).

Boiler	Heating surface	firebox	22.19 m² (238.9 sq. feet).
		tubes	262.09 m² (2 821.1 sq. feet).
		total	284.28 m² (3 060 sq. feet).
	Superheating surface		112.52 m² (1 211.2 sq. feet).
Tractive effort : $T = 0.75 \times \frac{p.\,d^2.\,l}{D} =$			23 053 kgr. (50 823 lb.).
Weight of the locomotive in working order	1st pair of wheels (leading)		17.3 t. (17.0 Engl. tons).
	2nd — —		22.6 t. (22.3 —).
	3rd — —		22.6 t. (22.3 —).
	4th — —		22.8 t. (22.4 —).
	5th — —		22.8 t. (22.4 —).
	6th — — (trailing)		22.4 t. (22.0 —).
		Total.	130.5 t. (128.4 Engl. tons).
Total weight, empty			118.1 t. (116.2 Engl. tons).
Total adhesive weight		(A).	90.8 t. (89.4 —).
Ratio $\frac{T}{A} =$			1 : 3.94

A No. 13 under-footplate injector is fitted on the right side.

The feed-pipes discharge into the forward dome in which is fitted a water softening device similar to that in use on the German Railways.

The exhaust is duplicated, consisting of two blast pipes of 135 mm. (5 5/16 inches) diameter, each discharging into a chimney of 440 mm. (17 5/16 inches) diameter.

The use of this double exhaust has been tried with success on the powerful locomotives types 10 and 36, of the Belgian National Railway Company. In the case of the type 5, it makes it possible to obtain through the blast pipes a total section of flow of 286.28 square cm. (44.5 sq. inches) which corresponds to a single blast pipe of 191 mm. (7 33/64 inches) diameter. As experience has shown, this arrangement makes it possible to work with low exhaust back pressures, without being obliged to place the blast pipe tops at too low a level.

The locomotive type 5 is fitted with the « Belge » (Flamme patent) superheater. This superheater has two distinct headers, one for the saturated, and the other for the superheated steam. Each header has a series of vertical branches situated in the space between two vertical rows of large tubes. The four tubes forming an element are coupled together as usual, by U bends, and are fitted at the collectors with spherical joints. There are only two sorts of elements, right and left, all being of the same length, which is advantageous from the point of view of spares,

The superheater tubes are 30.5/38 mm. (1 7/32 inches—1 1/2 inches) in diameter, and are carried inside the 128/137-mm. (5-inch — 5 25/64-inch) tubes. There are 43 elements for 170 smoke tubes of 50/55 mm. (1 31/32 inches—2 11/64 inches) making 1 element for 3.9 ordinary smoke tubes. The bend nearest to the fire-box is 450 mm. (17 11/16 inches) from the tube plate.

The proportions of the superheater are very large, but they appear to be reasonable on consideration of the large sections of the smoke tubes, of the great length of the tubes and of the normal use of a water-heater, which helps to increase the boiler output. With this increased output, each kilogramme of the combustion gases should assure the superheating of a greater weight of saturated steam, and thus the conclusions formulated above are justified.

It would have been possible to improve the superheater by decreasing the exterior diameter of the superheater-tubes, which would have made it possible to reduce the number of elements, but this solution was not adopted, because it would have had the disadvantage of increasing the fall of pressure while working, between the boiler and the steam-chest.

For service over steep gradients, such as the locomotive type 5 is called upon to give, it is extremely important that the boiler pressure should be as nearly as possible the same as that of the steam-chest. If this condition is not attained, it is necessary, for the engine to develop its full tractive force, to lengthen the cut-off; the working of the engine then becoming less economical, the boiler is unable to meet the demand, and the running times cannot be kept. The use of a superheater of large cross-section which reduces the loss of pressure to the steam-chest, and of the double exhaust which diminishes the back-pressure at the exhaust, appears to be particularly advantageous in the case which we are considering.

The regulator, situated in the rear dome, is of the usual type with balanced, double-seated valve; its operating gear, outside the boiler, is worked by a hand lever above the reversing gear. The steam dome is on the middle ring of the boiler barrel, to avoid carrying over water with the steam, which is more to be feared when changes of gradient are frequent and pronounced.

The boiler is secured in front, by the smoke-box, to the cylinder-block; it rests on two sliding blocks on a cross-member of the frame, behind the fourth coupled axle and further on four flexible plate supports, the last of which is under the back end of the foundation ring.

Motion. — The cylinders are of 720-mm. (28 3/8-inch) diameter, and the stroke is 720 mm. (28 3/8 inches). These dimensions have been chosen so as to give a ratio of mean tractive effort to adhesive weight of about 1/4, so that the engine could develop, on starting, an effort as great as its adhesion would permit.

The mean tractive effort, calculated by the usual formula

$$T = 0.75 \frac{pd^2l}{D}$$

is equal to 23 053 kgr. (50 822 lb.) The ratio of this effort to the adhesive weight is therefore equal to

$$\frac{23\,053}{90\,800} = \frac{1}{3.94}.$$

The lay-out of the cylinders has been done according to the American custom : they are fitted with inner liners.

Either cylinder can be used for either side. The piston valves are 330 mm. (13 inches) in diameter, being of the narrow-rings type commonly used in Germany, and which appear to be the type which is the tightest.

The cylinders are fitted with automatic steam-jet snifting valves, on the steam pipe, under the foot plate. The steam is injected through a 6-mm. (15-64-inch) nozzle into a cylindrical pipe in such a way as to assist the air to get to the cylinders. The introduction of steam into the steam chest has the additional advantage of preventing the lubricating oils from burning.

The supply of steam, regulated from the cab by means of a special valve, is only stopped during halts.

A similar arrangement has already been tried with success on many types of the Belgian State Railways locomotives.

By-passes of 70×140 (2 3/4×5 1/2 inches) have been fitted to the cylinders; they are of the non-automatic type, with cocks worked by a small compressed air cylinder.

The cylinder ends are fitted with relief valves 85 mm. (3 11/32 inches) in diameter.

The coned forged steel piston has been designed so as to reduce its weight as much as possible. With the same object the tail rod is bored out with a 60-mm. (2 3/8-inch) diameter hole. The tail rod is guided at the forward end in a closed air-tight sleeve, a simple arrangement used for many years on locomotives of the Belgian State Railways. The piston rod packing is of the « Crescent » type.

The driving rod, 3.200 m. (10 ft. 6 in.) in length, drives the third coupled axle.

Walschaerts valve-gear is used with a maximum cut-off of 78 %, in both fore and back gear.

Particulars of the valve motion are as follows :

Diameter of the piston valve	330 mm. (13 inches)
Width of the ports	55 mm. (2 11/64 inches)
Steam lap	40 mm. (1 37/64 —)
Exhaustlap	+ 2 mm. (5/64 —)
Lead	5.3 mm. (3/16 —)
Maximum stroke of the valve	180 mm. (7 3/32 —)

The weight-bar shaft is worked by a screw of the usual type.

In order to make it as easy as possible to work the reversing gears, the driver can, at will, let compressed air into a special cylinder acting directly on to a crank fixed on the weight-bar shaft.

Frame. — The frame is of the « bar » type. This type of frame, fitted to recently built locomotives of the Belgian State Railways, has been very satisfactory.

As well as the obvious advantages which result from the fact that all the inside parts of the frame are more visible and accessible, the following good features have been observed : this type of frame enables a really strong cylinder fastening to be used, even when the cylinders are very large; this is especially so when the cylinders are of the American pattern. The rigidity of this fastening contributes largely towards the horizontal cross-bracing of the frame.

The bar main side frames make it easy to fit spring gear with the springs placed above the boxes, which is a real advantage as regards maintenance work; further, since the centre plane of the frames coincides with the middle of the journals, the loads are transmitted to the boxes in a rational manner, and without unduly straining the main frames.

The locomotive type 5 has side frames 15 mm. (19/32 inch) thick made from rolled plates; they are crossbraced by box-type stays fore and aft, and by a number of cast steel stays.

Leading truck. — The leading truck is of American pattern, with triangular connections. Its load is transmitted to it by a longitudinal equaliser connected to the springs of the first coupled axle.

The truck frame is supported on the carrying-axle boxes through two concentric helicoidal springs.

The truck has a side play of 94 mm. (3 45/64 inches).

The side control gear worked by gravity has an initial load of 2 770 kgr. (6 106 lb.), and a maximum of 7 700 kgr. (16 976 lb.).

Trailing truck. — The trailing truck is also of an American (Cole and Scoville) type.

The trailing pair of wheels has outside journals. The truck frame includes the axle boxes. The springs are placed above the boxes, and are coupled by equalisers to those of the fourth coupled axle.

As the spring gear of the truck is carried on the principal frame of the locomotive, the back axle springs rest on a sliding block on the axle boxes, to allow for their movement; this sliding block is also articulated to allow for transverse movements of the truck relative to the frame.

The trailing truck allows of a displacement of 108 mm. (4 11/32 inches) on each side, and is fitted at the back with side control gear consisting of a helicoidal spring which gives initial and final centering forces of 950 and 1 935 kgr. (2 094 and 4 266 lb.).

Wheels and axles. — Having regard to the heavy loads on the driving and coupled wheels, these wheels have been fitted with thicker tyres than have ever before been used by the Belgian State Railways. This thickness has been raised form 76 mm. to 81 mm. (3 to 3 3/16 inches).

The truck wheel tyres have the usual thickness of 76 mm. (3 inches).

In order that the engine can run round the curves, the flanges of the second and third pairs of coupled wheels have been reduced by 15 mm. (19/32 inch). None of the coupled wheels has any side play.

Owing to these facts, and to the play given to the leading and trailing trucks, the locomotive can take a curve of 130 m. (6 1/2 chains) radius.

The leading dimensions of the journals and the crank-pins are given in the two tables below.

Axles.

DESCRIPTION.		Diameter on the tread.	Journals.		
			d	*l*	Centre to centre.
		mm.	mm.	mm.	mm.
Leading truck.	1st pair of wheels . .	900 (2 ft. 11 1/2 in.)	190 (7 1/2 in.)	360 (14 3/16 in.)	1 000 (3 ft. 3 3/8 in.)
Coupled axles.	2nd — — . .	1 700 (5 ft. 7 in.)	260 (10 1/4 in.)	325 (12 25/32 in.)	1 040 (3 ft. 5 in.)
	3rd — — . .	1 700 (5 ft. 7 in.)	260 (10 1/4 in.)	325 (12 25/32 in.)	1 040 (3ft. 5 in.)
	4rd — — (driving)	1 700 (5 ft. 7 in.)	305 (12 in.)	325 (12 25/32 in.)	1 040 (3 ft. 5 in.)
	5th — — . .	1 700 (5 ft. 7 in.)	260 (10 1/4 in.)	325 (12 25/32 in.)	1 040 (3 ft. 5 in.)
Trailing truck.	6th — — . .	1 262 (4 ft. 1 19/32 in.)	200 (7 7/8 in.)	350 (13 25/32 in.)	2 170 (7 ft. 1 7/16 in.)

Crank pins.

DESCRIPTION.	*d*	*l*	Distance between wheel centres.
	mm.	mm.	mm.
Connecting rods.	225 (8 7/8 in.)	200 (7 7/8 in.)	2 284 (7 ft. 5 29/32 in.)
Coupling rods : 1st pair of wheels	130 (5 1/8 in.)	130 (5 1/8 in.)	1 880 (6 ft. 2 in.)
— — 2nd — —	130 (5 1/8 in.)	130 (5 1/8 in.)	1 906 (6 ft. 3 in.)
— — 3rd — —	235 (9 1/4 in.)	130 (5 1/8 in.)	1 915 (6 ft. 3 25/64 in.)
— — 4th — —	130 (5 1/8 in.)	130 (5 1/8 in.)	1 880 (6 ft. 2 in.)

The layout of the coupled wheels has some interesting features : the power developed by the piston being very great, 57 000 kgr. (125 660 lb.), the crank pins had to be given a sufficiently large diameter (235 mm. [9 1/4 inches] at the

wheel seat). Further, owing to the high value of this force and to the heavy axle load, the diameter of the wheel seat has been raised to 315 mm. (12 25/64 inches). Although the radius of the crank-pin is rather large, 360 mm. (14 3/16 inches), relatively little material is left in the weel centres between the crank-pin and the axle, viz., 85 mm. (3 11/32 inches).

To ensure the wheel remaining tight, and at the same time providing in the wheel centre a crank capable of resisting the enormous forces to which it is subjected, the wheel boss and the crank-pivot hole have been connected by an elliptical shaped mass of metal.

With the object of lightening the driving wheels, a 90-mm. (3 35/64-inch) hole has been bored through the crank pin which allows of the balance-weights being lessened correspondingly : through the axle itself, a 75-mm. (2 61/64-inch) hole has also been bored.

Spring gear. — The load on the leading truck is carried as stated above, by two concentric helicoidal springs.

The springs for the coupled axles are 950 mm. (3 ft. 1 3/8 in.) in length, and have 17 plates, 120 × 10 (4 3/4 × 3/8 inches), those of the trailing axle are 1 400 mm. (4 ft. 7 1/8 in.) in length, and have 16 plates of 120 × 13 (4 23/32 × 1/2 inches).

The springs of the two first coupled axles are connected by equalising levers, one of which is transversal to those of the leading truck; those of the two last coupled axles are connected by equalisers to those of the trailing axle. This latter connection through equalisers consists of a transverse equaliser, behind the fourth coupled axle; this equaliser is not loaded in the middle, but at two points 330 mm. (1 ft. 1 in.) from either end.

Consequently the spring gear as a whole, may be taken as practically giving three points suspension.

Following the American practice, no adjustment has been provided on the spring pins.

Silicon-manganese steel has been specified for the spring plates.

Counterbalancing. — The counterbalancing of the reciprocating parts has been designed so that the additional load on each wheel shall not exceed 15 % of the static load at the maximum speed of 100 km. (62 miles) per hour. This rule only allowed about 18 % of the weights of the reciprocating parts to be balanced, although these parts have been made as light as possible.

Brakes. — The locomotive is equipped with the automatic and direct Westinghouse brakes. The coupled wheels alone are braked. The total braking force is equal to 65 % of the adhesive weight, and is obtained by means of two cylinders, 380 mm. (14 15/16 inches) in diameter, carried on a cross-member situated immediately behind the leading coupled axle. The pistons of these cylinders work on brake levers which turn on fixed transverse shafts.

The brake pump is of the Westinghouse Company's « Cross compound » type, and works with superheated steam. In order to do this, the saturated steam, the admission of which is controlled from the cab, by a valve of the usual type, passes through a superheater element set aside for this purpose, and in this way the steam arriving at the pump is superheated. This very simple arrangement has been tried out for several years on the Company's locomotives, and has given good results : the pump is preserved from the many drawbacks resulting from the use of steam heavily

laden with water, which adversely affects both maintenance and steam consumption.

Other fittings. — The locomotive is fitted with a pneumatic sander of the Gresham type, which supplies sand to all the coupled wheels; the sand reservoir is situated between the two domes. It is also fitted with a speed recorder, and a signal position indicator, of the Hassler type; with steam heating; with the Dilling arrangement for the injection of water into the smoke box, into the ash pan, and for watering the fuel; and two Superior soot blowers.

Smoke deflector screens have been fitted at the leading end of the locomotive. This arrangement tried in the first place by the German Railways, has been used with success on some locomotives of the Belgian Railway Company. As is known, these vertical screens project beyond the front of the smoke box and their vertical plane is slightly inclined towards the longitudinal centre line of the locomotive.

In order to give the staff some degree of comfort, a spring seat has been provided for the driver and fireman; further, the cab can be closed at the back by means of a canvas screen.

Dynamometer tests.

Dynamometer car tests have been carried out with locomotive No. 5501 type 5 over the Luxemburg line. These tests which were made with passenger trains actually weighing from 534 to 614 t. (525 to 604 Engl. tons), have shown that this locomotive is capable, in ordinary service, of hauling a train of 600 t. (590 Engl. tons) over this line, keeping to the timing of ordinary international trains which necessitates a sustained speed of 40 km. (25 miles) per hour on a 16 mm. (1 in 62) gradient.

They also demonstrated that the riding of the locomotive was perfectly steady up to the maximum speed of 100 km. (62 miles) per hour. This result, which *a priori* may appear astonishing for a locomotive with two outside cylinders, is to be attributed largely to the considerable wheel base given by eight wheels coupled, and to the excellent guiding provided by the leading truck, which is fitted with sufficiently powerful centralising gear.

The boiler was easily able to meet the demands.

The temperature of the superheated steam went up to 330 and 350° C. (626 and 662° F.). The back pressure at the exhaust did not exceed 300 gr. per cm² (4.27 lb. per sq. inch), at full power, on a 1 in 62 gradient.

The table below gives the general results of the dynamometer car trial carried out on 31 July 1930 between Brussels and Arlon and back :

Brussels-Arlon : train No. 6; load 614 t. (604 Engl. tons); 15 bogie carriages; 60 pairs of wheels.

Arlon-Brussels : train No. 61; load 534 t. (525 Engl. tons); 13 bogie carriages; 54 pairs of wheels.

Total work done at the tender draw bar hook	4 784 H. P.-hours
Total indicated work	7 200 —
Total consumption of fuel, including lighting up coal . .	19 583 lb.
Average fuel consumption per indicated H. P.-hour . . .	2 995 lb.
Average fuel consumption per tender drawbar H. P.-hour.	4 045 lb.

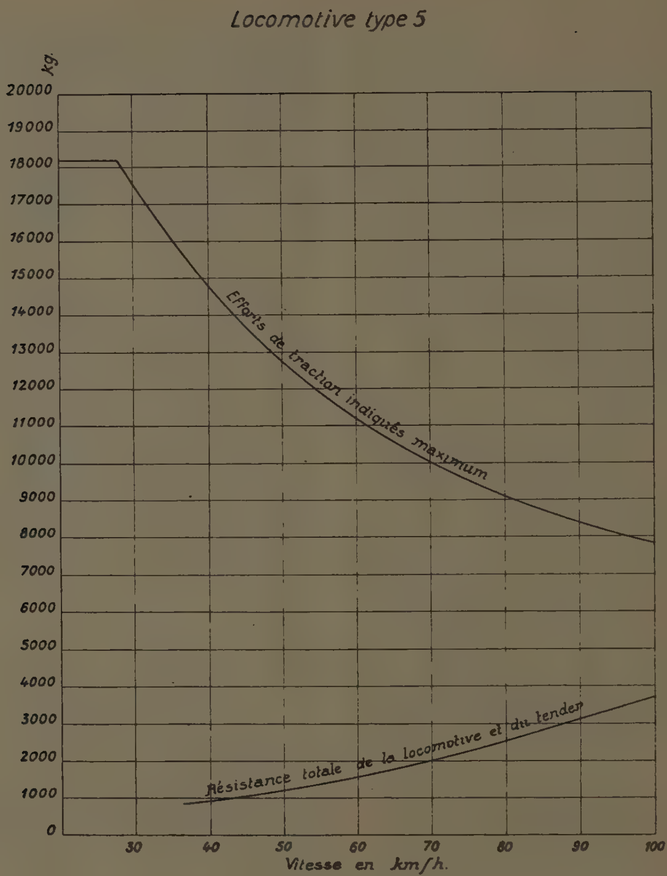
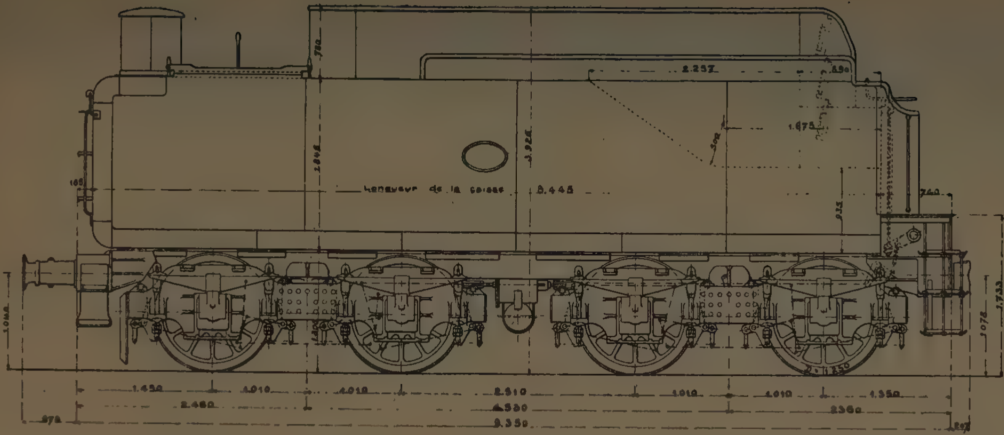


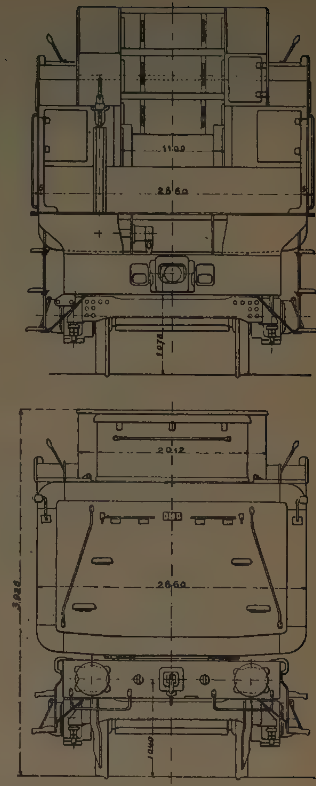
Fig. 4.

Explanation of French terms:

Efforts de traction indiqués maximum = Maximum indicated tractive efforts. — Résistance totale, etc... = Total resistance of the locomotive and tender. — Vitesse en km./h. = Speed in kilometres per hour.

When considering these results, it is necessary to remember that the consumptions given are average values, which are of course different from those which would be obtained under sustained favourable conditions. The figures as determined are influenced in an unfavourable way, not only by the consumption due to lighting up, and when standing, but also by the very considerable varia-





Water carried		38 300 l. (8 360 Br. gallons).
Coal carried		10 000 kgr. (9.84 Engl. tons).
Weight on the	1st pair of wheels	20 000 kgr. (44 090 lb.).
	2nd — —	20 000 kgr. (44 090 lb.).
	3rd — —	21 260 kgr. (46 870 lb.).
	4th — —	21 260 kgr. (46 870 lb.).
Total weight, working order		82 520 kgr. (181 925 lb.).
Total weight, empty		34 220 kgr. (75 440 lb.).

Fig. 5. — Tender, type 5.

tions in the power required from the locomotive. The time during the journey with regulator closed, reached in fact 36 % of the running nett time; moreover, on the sections of heavy gradient, the cut off had to be lengthened to as much as 50 %.

Compared, with the results obtained from dynamometer tests under absolutely analogous conditions, with other types of locomotives, the consumption of the type 5 locomotive seems to be normal.

Other dynamometer tests have had in view the determination of the resistance, with regulator closed, of the locomotive and tender, and of the diagram of maximum indicated tractive efforts. The results of these tests are shown in figure 4.

Tender of 38-m³ (8 360 Brit. gallons) (type 5). — Although this tender was intended for use with the type 5 locomotive, it has been so designed as to make it suitable from all points of view, for high speed passenger trains running up to 120 km. (75 miles) per hour.

The type 5 tender has two bogies, with 1.250-m. (4 ft. 1 3/16-in.) wheels; the wheel base of the bogies is 2.020 m. (6 ft. 7 1/2 in.), and the distance between bogie centres is 4.530 m. (14 ft. 3 11/16 in.).

The pivot of the forward bogie has ± 40 mm. (± 1 9/16 inches) side movement and is self centering.

The diagram as shown in figure 5, gives the general layout of the tender with the leading dimensions.

The tenders used so far by the Belgian National Railway Company with express engines were either 6-wheel rigid wheel base tenders (wheel diameter 1.067 m. = 3 ft. 6 in.), carrying 24 m³ (5 280 Br. gallons) of water, or bogie tenders with wheels 1 m. (3 ft. 3 3/8 in.) in diameter of the Prussian State Railways, holding 31.5 m³ (6 930 Br. gallons).

As these tenders were found of too small capacity for heavy express trains, it was considered desirable to increase the capacity to 38 m³ (8 360 Br. gallons) of water and 10 tons of coal. In addition the design of the 31.5-m³ (6 930-Br. gallon) bogie tenders was set aside in favour of a new design of greater strength and better running qualities.

The top of the type 5 tender is much like that of the French Nord Company's tenders [1]; the arrangement of the coal hole and the men's boxes alone was altered to make them conform with the Belgian National Railway Company's practice.

The body of the tender is carried on a frame built up in the usual way of rolled sections. The frame is carried at three points on the train of wheels formed by the two bogies. Two points of support are on the leading bogie 575 mm. (1 ft. 10 5/8 in.) on each side of the pivot, the bogie pivot only acting to carry the bogie with it; the third support is the bogie centre of the trailing bogie. Carried on three points in this way, the body is not exposed to any wracking through the transverse inclination of one bogie relatively to the other such as occurs particularly on parts of the line with superelevation at the beginning of curves.

The body has an outside casing of relatively thin plate (4 mm. [5/32 inch]) thick secured to an inner framing consisting of two longitudinal N girders cross braced with a number of N shaped stays.

The whole of this inner framing is built up of plates cut out of 5-mm.

(1) *Revue Générale des Chemins de fer* (January 1929): « Nouveaux tenders des machines de trains rapides de la Compagnie du Nord. » (New tenders for the express train locomotives of the Nord Company), by Mr. Cossart.

(3/16-inch) plate : it carries the load and has been designed with sufficient strength to be supported on the three points already mentioned without having to take into account the frame properly speaking.

The frame is built up of two longitudinal girders of 250 × 85 × 15 (9 7/8-in. × 3 3/8-in. × 5/8-in.) U sections connected at the leading and trailing ends by cast steel drag boxes which also carry the draw gear.

The longitudinal girders are further cross braced by two cast steel stays carrying the bogie pivots and by a central stay carrying the brake cylinder.

The whole of the tender body is cross braced in the usual way by 70 × 70 × 10 (2 3/4-in. × 2 3/4-in. × 3/8-in.) angles. As mentioned above, the frame is only intended to take draw and buffing stresses and to maintain the pivots in position.

The bogies have two cast steel frames connected by a cast steel center which carries the body. The two frames are connected at the ends by plate stays 20 mm. (25/32 inch) thick and the whole cross braced by 80 × 80 × 10 (3 5/32-in. × 3 5/32-in. × 3/8-in.) angles so as to make a thoroughly rigid unit able to stand the thrust of the wheels.

The wheels are 1.250 m. (4 ft. 29/32 in.) in diameter, and the journals have been made amply large : 170 × 350 (6 45/64 in. × 13 3/4 in.) which cannot but be an advantage for fast service.

The axle boxes are of American pattern. The bogie is carried on four separate springs placed above the boxes. These springs are 1.200 m. (3 ft. 11 1/4 in.) in length, and have 14 plates, 120 × 13 (4 3/4 in. × 33/64 in.).

As mentioned above, the weight of the body rests on the forward bogie on two points 575 mm. (1 ft. 10 5/8 in.) on each side of the centres and is transmitted to the bogie centre through two spherical roller ball and socket side bearings. The bogie pivot carries no load, and is only subjected to horizontal forces especially those needed to move the bogie.

This pivot can undergo a displacement of 40 mm. (1 9/16 inches) on each side of its centre line, and is self-centering by means of two horizontal plate springs arranged in pairs, an arrangement usual on locomotives.

The initial and final self-centering forces are 4 320 kgr. and 8 130 kgr. (9 524 and 17 923 lb.).

A self-centering centre was fitted to the leading bogie following the example of the Nord tenders, with the object of increasing as much as possible the stability of the tender when running through curves at high speed. The lateral displacement given to the centre makes it easier for the tender, when coupled to the locomotive, to take curves of small radius.

The centre of the trailing bogie is the third point of application of the load; it is built up in the usual way, a spherical shaped top centre rests in a lower centre of corresponding shape secured to the centre bolster. To avoid the possibility of the back bogie assuming a transverse inclination relative to the body, two spring spherical buffers are arranged at 575 mm. (1 ft. 10 5/8 in.) on both sides of the pivot; these buffers are not normally in contact with the bolster bogie, but have a clearance of 10 or 12 mm. (3/8 to 1/2 inch), their stroke being 15 mm. (5/8 inch).

The bolsters of the two bogies have been designed so that one pattern can be used, the differences resulting due to the different methods of making the bearings being met by attachments.

The body is higher than that of tenders used up to now by the Belgian National Railway Company, the height in fact being 3.196 m. (10 ft. 6 in.) to the upper edge of the tank filling hole with the tender fully loaded.

Brakes. — The tender is equipped with the automatic and direct Westinghouse brake.

The bogie wheels have two brake blocks per wheel, the brake gear exerting equal pressure on each block. The brake cylinder is 355 mm. (14 inches) in diameter; the total braking force is equal to 82 % of the tare of the tender.

The tender is also fitted with a hand-brake of the usual type, worked by wheel and screw.

[313 : 625 .143.3]

Statistics of rail breakages during the year 1929.[1]

(*Continued*).

We continue hereafter the publication of the statistics of rail breakages which occurred during the year 1929, the first part of which appeared in the number for March 1931, pp. 227 to 277.

For the sake of simplification and unless stated otherwise :

Light rails applies to rails of a weight less than 85 lb. per yard (42.5 kgr. per metre),

Medium rails, to rails of 85 to 105 lb. per yard (42.5 to 52.5 kgr. per metre),

Heavy rails, to those weighing 106 lb. per yard (53 kgr. per metre) or over.

(1) See *Bulletin of the Railway Congress*, March 1926, p. 240.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	ROAD.	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
New York Central Lines.			Miles.			Miles.			Miles.			Miles.			Miles		Pounds
Light rails	New York Central-East	...	...	...	7	195.10	22.00	10	416.40	15.00	29	393.50	46.00	10	32.83	190.00	64 000
	New York Central-West	...	...	...	...	...	...	...	...	...	...	6.00	...	...	1.00	...	65 000
	O. C. Lines	...	0.13	...	...	0.98	...	...	4.88	...	...	53.37	...	...	76.20	...	63 000
	Rutland	...	...	...	...	...	...	...	...	...	2	23.64	52.90	16	78.55	127.30	57 200
Medium rails	Rutland	3	113.90	16.46	...	119.11	...	1	61.00	10.24	3	16.77	111.80	...	...	...	57 200
	New York Central-East	118	902.65	82.00	159	1 655.95	60.00	28	768.90	23.00	85	326.89	163.00	12	23.00	326.00	64 000
	New York Central-West	9	635.00	8.86	44	932.00	29.51	14	275.00	31.82	5	88.00	35.51	...	79.00	...	65 000
	O. C. Lines	10	311.63	20.00	5	151.33	21.00	10	32.81	191.00	...	50.79	...	...	6.16	...	63 000
	Boston & Albany	24	287.64	52.15	7	193.63	22.60	5	12.98	240.70	1	7.60	82.23	...	...	...	62 800
	Pittsburgh & Lake Erie	...	...	...	...	...	...	4	7.02	356.40	1	7.30	85.61	...	...	...	62 500
	Cleveland, Cincinnati, Chicago & St. Louis	55	878.00	39.15	93	743.00	78.23	...	...	...	...	...	...	...	...	...	...
	Michigan Central	37	339.32	68.15	159	551.60	180.16	3	43.25	43.35	...	...	...	...	...	...	62 000
	Indiana Harbor Belt	2	42.89	29.00	3	23.19	81.00	...	0.64	...	...	0.27	...	...	0.20	...	60 000
Heavy rails	New York Central-East	107	608.05	110.00	9	89.90	63.00	...	...	...	...	...	...	...	...	...	64 000
	New York Central-West	6	472.00	7.94	...	9.00	...	...	...	...	...	...	...	...	...	...	65 000
	Pittsburgh & Lake Erie	...	223.82	...	5	209.19	14.94	...	...	...	...	...	...	...	...	...	62 500
	Cleveland, Cincinnati, Chicago & St. Louis	...	16.00	...	...	...	...	...	...	...	...	...	...	...	...	...	... 62 000
	Michigan Central	10	302.47	20.66	...	...	...	...	...	...	...	...	...	...	...	...	

ROAD.	Total number of fractures.	Number of fractures per 10 000 000 trains-kilometres or 6 250 000 train-miles.
New York Central-East	574	90.3
New York Central-West	78	21.57
New York Central - O. C. Lines	25	48.0
Boston & Albany	37	37.0

ROAD.	Total number of fractures.	Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles.
Pittsburg & Lake Erie	10	19.55
Cleveland, Cincinnati, Chicago & St. Louis	148	62.00
Michigan Central	209	No data.
Indiana Harbor Belt	5	7.65
Rutland	25	87.52

Note. — The information submitted above, as in past years, covers rail fractures which have developed in many different rail sections of varied design and composition, as well as manufacture. The rails, of course, are located in tracks over which all types of service are operated, both light and heavy traffic, slow and high speed tracks, on tangents and curves of various degrees, and with varying subsoil and ballast conditions.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
GREAT BRITAIN AND NORTH OF IRELAND. Great Western Railway.																English tons.
Light rails	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	16
Medium rails	...	...	...	1	...	...	1	...	...	3	...	...	10	...	...	22.5
Total	1	...	...	1	...	...	1	...	...	3	...	...	10	...	...	...

Number of train-miles : 65 617 082.
Total number of fractures : 16.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 1.52.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London and North Eastern Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	36.59	...	...	35.09	...	...	44.25	...	...	87.25	...	4	1 499.76	1.67	20
Medium rails	5	1 671.65	1.87	7	1 302.77	3.36	5	1 209.14	2.58	4	1 562.94	1.60	10	3 033.19	2.06	22.5
Total	5	1 708.24	1.83	7	1 337.86	3.27	5	1 253.39	2.49	4	1 650.19	1.52	14	4 532.95	1.93	...

(*) In running lines.

Number of train-miles : 110 866 219.
Total number of fractures : 35.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 1.97.

Rails are broken when : *a*) completely severed from top to bottom ; *b*) also when a piece of the head is broken away leaving a gap in the running surface. — *Broken rails in sidings not included.*

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Southern Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	7	205	21.3	...
Medium rails	4	865	2.9	2	930	1.4	6	224	17.5	4	593	4.2	1	1 184	0.5	25.1

Number of train-miles : 58 283 134.
Total number of fractures : 24.

A. — Percentage of breakages in the respective portions of the rails covered by, and clear of, the fishplates:

Breakages covered by fishplates : 22 = 91 1/2 %.
Breakages clear of fishplates : 2 = 8 1/2 %.

B. — Number of fractures according to the appearance of the section:

a) Fresh and clean fracture through the whole of the rail section :

1. With silvery oval mark : Nil
2. Without silvery oval mark : 14

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.58.

b) Fractures, part of which is old and much rusted, extending to the outer face of the foot or head of the rail :

1. When the rusted part is in the foot : 4
2. When the rusted part is in the head : Nil

c) Fractures with much rusted portions not extending to the outer surface of the foot or head of the rail : 2

Breakages not classified in types *a*, *b* and *c* : 4

Total : 24

d) The number of pieces into which the rail is broken :

Two pieces : 16
Three pieces : 3
Four pieces : 1
Five pieces : 2
Seven pieces : 2
Total : 24

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1																
Cheshire Lines Committee.	No breakages in 1929.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Northern Railway (Ireland). (*)														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	1	141.881	4.405	14.75

(*) In passenger train lines.

Number of train-miles : 4 085 435.

Total number of fractures : 1.

A. — Percentage of breakages in the respective portions of the rails :

1. Covered by the fishplates . . . . 100 %
2. Clear of the fishplates . . . . Nil.

B. — Percentage according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section : Nil.

1. With silvery oval mark . . . . } ...
2. Without silvery oval mark . . . . }

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 1.529.

b) Fractures, part of which is old and much rusted, extending to the outer surface of the foot or head of the rails :

1. Rusted part in the foot . . . .
2. Rusted part in the head . . . .

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail . . . . 100 %

d) Number of pieces into which the rail is broken : 2.

1	
Kent, Somerset, Shropshire & Welsh Light Railways Group.	No fractures occurred in 1929.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Underground Electric Railways Company of London (District Railway and Tube Railways).		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Medium rails:																Dist. Ry.: 11.25 Tube Rys: 11.50
District Railway	1	12.5	50.00	...	20.0	...	...	12.0	...	...	10.0	...	...	...	...	
Tube Railways	1	51.0	12.2	...	10.0	...	...	6.00	...	3 [1]	5.0	375	2	32.7	38.0	

Number of train-miles: District Railway: 4 700 000.
— — Tube Railways: 13 210 000.

Total number of fractures: District Railway: 1.
— — Tube Railways: 6.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles:

District Railway . 1.33.
Tube Railways : 2.84.

County Donegal Railways Joint Committee.	No fractured rails in 1929.

[1] Bridge rails, 100 lb. per yard.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London Midland and Scottish Railway (Northern Counties Committee), Ireland.											Miles.			Miles.		English tons.
Light rails :	...	...	...	...	...	...	...	...	...	...	...	...	13	217.17	37	17.75

Number of train-miles : 1 644 988.
Total number of fractures : 13.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 49.

B. — Percentage of fractures according to the appearance of the fracture :

b) Fractures, part of which is old and much rusted, extending to the outer surface of the foot or head of the rail :

1. Rusted part in the foot : 62 %.

c) Fractures with much rusted portions not extending to the outer surface of the foot or head of the rail : 38 %.

d) Number of pieces into which the rail is broken : 10 into 2 pieces, and 3 into 3 pieces.

INDIA, DOMINIONS, PROTECTORATES AND COLONIES

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AFRICA.

Gold Coast Government Railways. — No broken rails in 1929

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kenya and Uganda Railways and Harbours.		Miles.												Miles.		English tons.
Light rails	3	332	5.65	...	...	...	...	...	...	...	...	...	8	1174	4.21	80-lb. rails : 18 50-lb. rails : 10

Number of train miles : 3 896 535.
Total number of fractures : 11.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	SECTION OF LINE.	Length of section.	NUMBER OF FRACTURES AND PARTICULARS OF TRAC[K]															
			AGE OF RAILS :															
			Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years		
			Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		Miles.		Miles.													
Beira and Mashonaland and Rhodesia Railways.																	
	Beira-Villa Machado. . .	61	...	...		...	...	...	...	...	...	...	...		...	61	
	Villa Machado-Umtali . .	143	2	94 3/4		...	...	...	...	...	...	...	...		1	48 1/4	
	Umtali-Salisbury.	170	...	75 3/4		...	...	...	...	...	...	...	...		8	94 1/4	
	Salisbury-Bulawayo . . .	298	...	12 1/4		...	...	...	...	...	...	...	...		40	285 3/4	
	Bulawayo-Livingstone. .	288	...	34 1/2		...	80	...	...	...	...	...	...		7	173 1/2	
	Livingstone-Broken-Hill.	368	...	44 1/2		...	...	...	...	...	...	...	...		11	323 1/2	
	Broken Hill-Congo Border	132	...	41		...	...	...	...	...	...	1	91		...	...	
Light rails :	Selukwe Branch (S. H. Rail).	23 1/4	...	...		...	...	...	...	...	...	...	...		...	23 1/4	
	West Nicholson Branch .	102 3/4	...	...	Not expressed.	...	...	...	...	...	...	...	...	Not expressed.	1	102 3/4	Expressed in total.
	Lomagundi Branch (S. H. Rail).	83	...	...		...	...	...	...	...	...	...	...		2	83	
	Blinkwater Branch. . . .	123	...	...		...	...	...	...	...	...	...	123		...	...	
	Mazoe Branch	73	...	...		...	...	...	...	...	...	...	73		...	...	
	Shabani Branch	63	...	63		...	...	...	...	...	...	...	...		...	...	
	Luanshya Branch (S. H. Rail).	23 3/4	...	...		...	...	...	...	...	...	...	...		..	23 3/4	
	N'kana Branch (S. H. Rail)	...	...	...		...	...	...	...	...	...	...	...		...	...	
		1951 3/4	2	365 3/4	...	...	80	...	...	...	...	1	287	...	73	1219	37

Number of train-miles : 5 412 103. — Total number of fractures : 76.

(1) Except 2 in 4 pieces.

Note : Trucks with axle loads of 13 tons 18 cwt. [...]

D RAILWAY.

Classification according to part II of the suggestions adopted at the General Meeting of the London Congress in 1925.

Train-miles per section.	Maximum axle load (engines).	Maximum speed of trains permitted.	REMARKS.	A — Percentage of fractures in respective portions of the rails covered by and clear of the fishplates. a) Percentage, covered by fishplates.	b) Percentage, clear of fishplates.	B — Percentage of fractures according to the appearance of the fracture: a) Fresh and clean fracture through whole of rail section.	b) Fractures part of which is old and much rusted, extending to outer face of foot or head of rail.	c) Fractures with much rusted portions not extending to outer face of foot or head of rail.	d) Number of pieces into which rail is broken.
19	20	21	22	23	24	25	26	27	28
	Tons. Cwt.	Miles per hour.							
153 666	9—12	30	...	...	...	...	...	...	...
463 244	13—10	30	...	...	100.00	66.67	33.33	...	2 pieces.
705 802	13—10	35	...	25.00	75.00	25.00	75.00	...	2 pieces.
975 086	13—00	35	...	52.50	47.50	77.50	22.50	...	2 pieces.
025 770	13—00	35	...	28.57	71.43	57.14	42.86	...	2 pieces.
306 053	13—00	35	...	21.43	78.57	85.71	14.29	...	2 pieces (1)
475 603	12—18	35	...	...	100.00	100.00	...	...	2 pieces.
30 524	12—18	25	...	...	...	...	...	...	...
43 556	12—18	30	Engines of 13 tons axle load run occasionally on this branch.	...	100.00	100.00	...	...	2 pieces.
57 407	12—18	30	...	...	100.00	100.00	...	...	2 pieces.
73 239	12—01	30	Engines of 12 tons 18 cwt axle load run occasionally on this line.	...	...	...	...	...	...
62 471	12—18	30	Engines of 13 tons axle load permitted to run occasionally at 25 miles per hour.	...	...	...	...	...	...
27 226	12—18	25	...	...	...	...	...	...	...
9 456	12—18	30	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
12 103	...	...	...	36.84	63.16	69.74	30.26	...	...

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: not expressed.

d to full capacity run over all sections of the line.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nigerian Railway.		Miles.						Miles.			Miles.					English tons.
Light rails.	9	698	8	...	258	...	2	151	8.2	10	595	10.5	1	88	7.1	16

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Length of single track.	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Age unknown. (Roll marks obliterated). Number of fractures.	Age unknown. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
South African Railways and Harbours.	Miles.													English tons.
Light rails: 35-46 1/4 lb.	2 611	2	0.48	2	0.48	5	1.20	38	9.10	70	16.75	51	12.21	10.5
Medium rails: 60-61 lb.	6 298	8	0.79	3	0.30	6	0.60	9	0.89	126	12.50	72	7.15	13.5
Heavy rails: 75-85 lb.	4 254	29	4.26	36	5.28	23	3.37	101	14.82	39	5.72	25	3.67	18.5
Total. . .	13 163	39	1.85	41	1.95	34	1.61	148	7.02	235	11.15	148	7.02	...

Total number of fractures of all classes of rails : 645.
Number of train-miles for year ended 31-12-29 : 52 668 288.

Number of fractures per 6 250 000 train-miles : 76.54.

NOTE : The above fractures include those occurring in sidings as well as in running tracks.
The table covers all instances of rails removed from the track on account of fractures even though the rails may not have been completely broken into two or more portions.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years Number of fractures.	More than 20 years Length of single track of this class.	More than 20 years Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	[illegible]	[illegible]	[illegible]	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
AUSTRALASIA.																
New South Wales Government Railways.																
Light rails	2	6 042	0.207	2	6 042	0.207	...	6 042	...	15	6 042	1.55	32	6 042	3.31	20.35
Medium rails	2	673	1.86	4	673	3.71	1	673	0.93	1	673	0.93	2	673	1.86	20.35
Total. . .	[illegible]	6 715	0.37	6	6 715	0.56	1	6 715	0.093	16	6 715	1.49	34	6 715	3.16	...

Number of train-miles : 27 344 120

Total number of fractures : 61.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 13.94.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
New Zealand Government Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	352	...	1	349	1.8	3	208	9	13	699	11.6	76	1 745	27.2	14
Medium rails	..	10	...	...	1	...	...	...	...	...	...	...	...	...	...	14
Total	[illegible]	...	...	1	...	...	3	...	...	13	...	...	76	...	...	...

No rails over 100 lb. per yard in use.
Number of train-miles : 16 385 000.
Total number of fractures : 93.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 35.4.
Number of fractures at joints : 65 (70 °/. of total).
Number of fractures away from joints : 28 = 30 °/. of total.

PARTICULARS OF THE FRACTURES.		Number.	Percentage of total.
a) Fresh and clean fracture in the whole of the rail section	with silvery oval mark	1	1
	without silvery oval mark	6	6
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	38	41
	in the head	33	36
c) Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail		15	16
	Total	93	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CANADA.		Miles.			Miles.			Miles.			Miles.			Miles.		
Canadian National Railways (1).																
Light rails (2)	...	...	..	...	2	...	3	15	125	2854	1 884	947	12 027	5 084	1 479	...
Medium rails	965	3 825	158	2461	3 287	468	3285	1 083	1 896	343	165	1 299	1701	1 551	685	...
Total	965	3 825	158	2461	3 289	468	3288	1 098	1 872	3197	2 049	975	13 728	6 635	1 293	...

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quebec Central Railway.		Miles.									Miles.			Miles.		Pounds.
Light rails	...	...	...	...	...	...	...	...	...	5	102	30.5	13	93	86.5	50000
Medium rails	1	65	9.5	...	...	...	...	...	...	7	75	57.8	...	...	...	50000
Total	1	65	9.5	...	...	...	...	...	...	12	177	42.0	13	93	86.5	...

Total number of fractures : 26.
Number of train-miles : 983 113.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 164.33.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Canadian Pacific Railway (3).		Miles.			Miles.											Pounds.
Light rails	No record kept.															
Medium rails	25	2 041.81	7.653	173	1 611.07	67.153	...	...	...	...	...	...	...	...	...	63 000
Heavy rails	No heavy rails in use.															

(1) Fractures which occurred in the course of the *seven months ending 31 December, 1929.*
(2) Figures on this line include failures to *80-lb. rails only.*
(3) Year ending 31 October, 1929.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	[illegible]	10	11	12	13	14	15	16	17
Jamaica Government Railways.		Miles.												Miles.		English tons.
Light rails	1	15	41.7	...	...	...	...	...	...	...	...	...	1	40	15.6	13.5
Asia.																
CEYLON.																
Ceylon Government Railways.																
Light rails:																
46 1/4 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	5	...	...	8 1/2
72 and 80 lb. per yard.	...	...	...	...	...	...	...	...	...	2	...	...	5	...	...	14
Medium rails:																
88 lb. per yard.	...	...	...	4	...	...	...	...	...	2	...	...	...	...	..	16
Total. . .	...	...	...	4	...	...	...	...	...	4	...	...	10	...	...	...

Number of train-miles : 4 887 333.
Total number of fractures : 18.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 23.02.

Bengal and North Western Railway.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails	2	442.86	2.82	...	1.11	...	...	44.10	...	2	150.23	8.26	15	1 438.42	6.52	...

Number of train-miles . 7 765 230.
Total number of fractures : 19.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 15.29

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bombay, Baroda and Central India Railway. (Broad gauge.)											Miles.			Miles.		English tons.
Light rails.	...	...	...	...	...	...	...	...	...	1	675.085	0.93	1	675.085	0.93	17.2
Medium rails	...	...	...	...	...	...	...	...	...	4	1 255.584	1.99	2	1 255.584	0.99	17.75
Total. . .	...	...	...	...	...	...	...	...	...	5	1 930.669	2.91	3	1 930.669	1 91	...

Number of train-miles on the whole of the broad gauge system for the year ending 31 December 1929 : 8 759 605.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 5.71.

Total number of fractures during the year ending 31 December 1929 : 8.

Note. — It is not possible to give percentage of fractures in the respective portions of the rails covered by and clear of the fishplates; percentage of fractures according to the appearance of the fracture is not available.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load.*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
								Miles.			Miles.			Miles.		English tons.
Bombay, Baroda and Central India Railway. Metre (3 ft. 3 ⅜ in.) gauge system.																
Light rails :																
of a weight of :																
41 ½ lb. per yard.	...	...	...	...	...	...	...	1 160.46	...	...	1 160.46	...	14	1 160.46	7.54	8
50 lb. per yard.	...	...	...	...	...	...	1	1 247.32	0.50	...	1 247.32	...	25	1 247.32	12.52	10
60 lb. per yard.	...	...	...	...	...	...	...	454.27	...	...	454.27	...	...	454.27	...	12
Total.	...	...	...	...	...	...	1	2 862.05	0.22	...	2 862.05	...	39	2 862.05	8.47	...

Number of train-miles : 10 071 000.
Total number of fractures : 40.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 24.82.

Notes. — All fractures were outside the portion covered by the fishplates. — Percentage of fractures according to the appearance of the section is not available.

12-ton axle YC class engine is allowed between Phulera and Sojat Road only. On the remaining portion of the main line, Agra Branch and Rewari Phulera Chord, 10 ton and 10.5-ton engines are running.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Burma Railways.					Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :																
50 and 60 lb. per yard.	...	...	...	1	2 762	0.226	2	2 762	0.453	1	2 762	0.226	7	2 762	1.92	10

Number of train-miles : 8 629 299.
Total number of fractures : 11.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 7.967

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Eastern Bengal Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails	7	1 950.43	2.24	1	1 950.43	0.32	1	1 950.43	0.32	14	1 950.43	4.48	6	1 950.43	1.92	17.75
Medium rails.	..	...	...	3	1 014.33	1.84	4	1 014.33	2.46	8	1 014.33	4.92	1	1 014.33	0.61	17.75

Number of train-miles : 22 417 172.
Total number of fractures : 45.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 12.54.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
East Indian Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		
85 and 87 lb	...	783	...	...	783	...	1	783	1	...	783	...	9	783	7	...
88 1/2 lb	...	952	...	...	952	...	...	952	...	1	952	1	...	952	...	...
90 lb.	8	1 270	4	11	1 270	6	4	1 270	2	7	1 270	4	...	1 270	...	...
100 lb	...	250	...	2	250	...	...	250	...	...	250	...	...	250	...	...
	8	3 255	...	13	3 255	...	5	3 255	...	8	3 255	...	9	3 255	...	...

(*) Year 1929-1930.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
																English tons.
Great Indian Peninsula Railway. (*)	Age of rails (from year of manufacture).															
Light rails :																
62 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	13.5
69 lb. —	1	...	...	...	...	...	...	...	...	...	...	...	15	...	...	15.5
75 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	8	...	...	17
80 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	21	...	...	18.5
82 lb. —	1	...	...	1	...	...	3	...	...	...	...	...	...	...	...	19.3
85 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	20.5
	2	...	...	1	...	...	3	...	...	...	...	...	48	...	...	...
Medium rails :																
90 lb. per yard	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	22.5
100 lb. —	4	...	...	4	...	...	...	...	...	...	...	...	...	...	...	25
	5	...	...	4	...	...	1	...	...	...	...	...	...	...	...	...

(*) Year ended 31 December 1929.

Number of train-miles : 24 337 973.
Total number of fractures : 64.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 24.92.

RAILS OF :								
—	62 lb.	69 lb.	75 lb.	80 lb.	82 lb.	85 lb.	90 lb.	100 lb.
Miles of railway including sidings	80	500	440	900	1 300	121	692	1 232

A) The above table shows the total mileage of each section of rails in use on the Great Indian Peninsula Railway, and on which there were fractures. — B) It is not possible to give the total mileage according to age as no record exists, but no rails of the following sections were ordered or purchased for the last 21 years : 60, 62, 69, 75, 80, and 85 lb. The last year of purchase of 82-lb. rails was 1923-1924.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Madras and Southern Mahratta Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	468.76	...	1	290.71	2.15	...	118.25	...	1	230.25	2.71	17	1 620.16	6.56	17.95
Medium rails	...	259.88	...	2	147.50	8.47	...	31.00	...	...	...	...	...	...	...	17.95
Total . . .	...	728.64	...	3	438.21	4.28	...	149.25	...	1	230.25	2.71	17	1 620.16	6.56	...

Number of train-miles : 13 807 000.
Total number of fractures : 21.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 9.51.

CLASSIFICATION OF BREAKAGES.

	Total number of breakages.	A. Percentage of breakages.		B. Percentage of fractures as per appearance.				
				a) Fresh and clean		*b*) Fractures parts of which is old and much rusted.		*c*) Percentage of fractures with much rusted portions not extending to the outer face of foot or head.
		Covered by fishplate.	Clear of fishplate.	1. With silvery oval mark.	2. Without silvery oval mark.	1. Rusted part in the foot.	2 Rusted part in the head.	
Light rails	19	10.53	89.47	5.26	...	42.10	31.58	21.06
Medium rails	2	50.00	50.00	...	...	...	100.00	...
Total. . .	21	14.29	85.71	4.76	...	38.09	38.10	19.05

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
North Western Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	313.02	...	1	344.15	1.82	2	272.03	4.59	3	697.56	2.69	22	3 401.49	4.04	17.7
Medium rails	3	542 84	3.45	1	512 5	1 22	4	374.75	6 67	5	627.75	4 98	6	630.00	5.95	22.5
Total. . .	3	855.86	...	2	856.65	...	6	647.05	...	8	1 325.31	...	28	4 031.49	...	...

(*) Year ending 31 March 1930.

Number of train-miles : 30 184 328.
Total number of fractures : 47.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 9.73.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rohilkund and Kumaon Railway.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	1	571.94	1 09	9.5

Number of train-miles : 1 499 395.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 4.17.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
South Indian Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	3	599.98	3.12	...	145.31	...	1	152.65	4.08	...	120.00	...	4	1 591.41	1.56	(1)
Medium rails	...	96.68	...	...	82.24	..	...	...	...	...	...	...	...	0.25	...	...

Number of train-miles : 11 238 260.
Total number of fractures : 8.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 4.44.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MALAY PENINSULA. Federated Malay States Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	1	135	...	...	103	...	...	121	...	...	145	...	1	610	1.025	16 tons, but 12 tons over the portions of the line over 5 years old.

Number of train-miles : 6 603 695.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 0.95.

IRISH FREE STATE.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Southern Railways.														Miles.		English tons.
Light rails	...	..	...	...	...	...	...	...	...	...	...	...	19	1 281.71	9.26	18.5

Number of train-miles : 9 607 797.
Total number of fractures : 19.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 trains-miles : 12.31.

(1) 80 lb. . . . . 17.87 tons; 75 lb. . . . . . . 16.62 tons; 60 lb. . . . . 15.55 tons } Broad gauge.
60 lb. . . . . 10.00 tons; 41 1/4 lb. . . . . 8.15 tons } Metre gauge.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
GREECE State Railways. (*)														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	6	165.9	22.5	14.8
Medium rails	1	164.7	3.8	...	...	...	...	...	...	...	...	...	...	...	...	14.8

Note. — 1. Fractures at joints : None.
2. New and clean breakages in the whole of the rail section, without oval mark : 4.
3. Fracture with rusted portion in the foot of the rail : 1.
4. Fractures due to excessive wear of the head owing to skidding : 2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Salonique-Alexandrople Line.																English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	11	276.5	17.9	13.8
Salonique-Florina Line																
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	2	125.5	9.9	13.8
Total . . .	...	...	...	...	...	...	...	...	...	...	...	...	13	402.0	20.10	...

Number of train-miles { Salonique-Alexandrople : 786 477
Salonique-Florina : 317 941
Total 1 104 418

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 73.13.

Total number of fractures : 13.
* 1 April 1929 to 31 March 1930.

NAMES ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															Maximum axle load
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Piræus-Athens-Peloponnesus Railway.														Miles.		English tons.
Light rails.	...	...	...	...	...	...	...	..	...	...	...	...	78	466	105	9.8

Number of train-miles : 2 605 875.
Total number of fractures : 78.

Note. — Our rails weigh 40 lb., 50 lb. and 55 lb. per yard ; most of then date from 1884.

CHARACTERISTICS OF THE FRACTURES.

Percentages of fractures in relation to their distance from the rail end.

7 °/₀ at the joint.
18 °/₀ at a distance of 1 m. (3 ft. 3 3/8 in.) from the rail end.
27 °/₀ — 1 to 2 m. (3 ft. 3 3/8 in. to 6 ft. 6 3/4 in.) from the rail end.
12 °/₀ — 2 to 3 m. (6 ft. 6 3/4 in. to 9 ft. to 1/8 in.) from the rail end.
8 °/₀ — 3 to 4 m. (9 ft. 10 1/8 in. to 13 ft. 1 1/2 in.) from the rail end.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Thessaly Railways.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	20	125.5	99.01	9.2

Number of train-miles : 278 422.
Total number of fractures : 20.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 446.36.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Rails in use for: Less than 5 years. Number of fractures.	5 to 10 years. Number of fractures.	10 to 20 years. Number of fractures.	20 to 30 years. Number of fractures.	More than 30 years. Number of fractures.	TOTAL.	Approximate length of the lines considered as single lines.	Number of fractures per 1 000 km. or 625 miles	*Maximum axle load in service.*
1	2	3	4	5	6	7	8	9	10
ITALY. State Railways.							Miles.		
Light rails	6	19	65	103	933 (1)	1 126	8 200	85.3	16.2
Medium rails :									
In tunnel	1	71	150	1	...	223	205	675.7 } 41.9	16.7
In the open	10	11	34	2	...	57	3 947	8.9	...
Total. . .	11	82	184	3	...	280	4 152	41.9	...
Total general. . .	17	101	249	106	933	1 406	12 352	70.7	...

Number of train-miles : 89 635 645.
Total number of fractures : 1 406.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 97.4.

Note. — Nearly all the fractures of heavy rails occurred in tunnels (223 on 205 miles of track), in which unfavourable conditions besides dampness due to water infiltration, make maintenance very difficult, whereas in the open only 57 breakages on 3 947 miles of track, occurred.

1) Most of these rails were put into service more than forty years ago.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															Maximum axle load.
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
Mediterranean Railway.	No rail breakages in 1929.															
North of Milan Railway.	So far no statistics have been drawn up, as few fractures of rails occur on our lines.															
Tessin Railway.	No fractured rails in 1929.															
Società Trazione Elettrica Lombarda.	No fractures in 1929. — Maximum axle load : 8.9 English tons. — Number of train-miles : 2 299 100.															
Tranvie Elettriche Bresciane.	No rail breakage in 1929.															
1	2	3	4	5	6	7	[illegible]	[illegible]	10	11	12	13	14	15	16	17
Ferrovie Salentine (Gestione Governativa).		Miles.									Miles.					English tons.
Light rails	...	42 9	...	...	...	...	...	...	...	...	111.8	...	...	...	...	14.7

Number of train-miles : 397 394.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
JAPAN. Japanese Government Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	31	3 089.0	6.2	63	2 352.4	16.6	55	827.4	41.2	61	877.8	43.1	114	2 567.9	27.8	16.41
Medium rails.	5	497.9	6.2	1	29.5	21.1	...	...	...	...	...	...	...	...	...	...

Number of train-miles : 112 206 300.
Total number of fractures : 330

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 18.3.

Percentage of fractures of rails covered by and clear of fishplates :

Damaged part of rails:	Percentage.	*Remarks.*
Covered by fishplates	28.5	This is based on statistics of rail breakages in *1929*.
Clear of fishplates	71.5	
Total. . . .	100.00	

Percentage of fractures according to the appearance of the fracture :

	Light rails. In 1929	Medium rails. In 1929
a) Fresh and clean fracture through the whole of the rail section, with silvery oval mark	19 5 %	...
b) Fresh and clean fracture through the whole of the rail section, without silvery oval mark .	8.2 %	...
c) Fractures, part of which is old and much rusted, extending to the outer surface of the rail, with the rusted part in the foot	4.0 %	...
d) Fractures, part of which is old and much rusted, extending to the outer surface of the rail, with the rusted part in the head	16 %	0.6 %
e) Fractures with much rusted portions not extending to the outer surface of the foot or head of the rail.	29.0 %	0.3 %
f) Rails broken into several pieces	21.5 %	0.9 %

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Chosen Government Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	7	398.5	10.9	14	111.0	77.6	17	212 0	49.8	37	355.6	64.7	37	641.9	35.8	19
Medium rails	...	44.9	...	...	48.1	...	...	...	...	...	...	...	...	...	...	...
Total. . .	7	443.4	9.8	14	160.1	54.3	...	212.0	49.8	37	355.6	64.7	37	641.9	35.8	...

Number of train-miles : 10 796 170 miles.
Total number of fractures : 112.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 64.5.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
LUXEMBURG. Guillaume-Luxemburg Railways.	(See under « Alsace and Lorraine Railways ».)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Prince Henry Railways and Mines.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	21.6	...	...	9.8	...	3	18.9	98.3	...	22.4	...	5	17.6	176.9	15.7
Medium rails	...	31.8	...	...	4.3	...	...	10.4	...	...	1.6	...	...	...	...	15.7
Total	...	53.4	...	...	14.1	...	3	29.3	63.5	...	24.0	...	...	17.6	...	...

Number of train-miles : 930 024.
Total number of fractures : 8.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 trains-miles : 53.3.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NORWAY. State Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails.	6	2175	1.7	25	2175	7.1	63	2175	18	15	2175	4.3	18	2175	5.1	17.7 (appr.)

Number of train-miles : 8 699 000.
Total number of fractures : 127.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 91.

CHARACTERISTICS OF THE FRACTURES.

A. — Percentage of fractures in the respective portions of the rails :
1. Covered by the fishplates . . . . 11 %.
2. Clear of the fishplates . . . . 89 %.

B. — Fractures according to the appearance of the section :
a) Fresh and clean fracture through the whole of the rail section . . . . 86 %.
1. With silvery oval mark . . . . 0 %.
2. Without silvery oval mark . . . . 86 %.

b) Fractures, part of which is old and much rusted, extending to the outer surface of the foot or head of the rail . . . . 11 %.
1. Rusted part in the foot . . . . 10 %.
2. Rusted part in the head. . . . . 1 %.

c) Fractures with much rusted portions not extending to the outer surface of the foot or head of the rail. . 3 %.

d) Number of pieces into which the rail is broken :
In 2 pieces . . . . 96 %.
— 3 — . . . . 1 %.
— 4 — . . . . 2 %.
— 5 — . . . . 1 %.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
HOLLAND.																
Netherlands Railways. (Netherlands State Railway Company and Dutch Railway Company)																
Light rails	0	107	0	14	441	20	11	175	39	41	690	37	215	963	139	15.7
Medium rails	5	188	17	15	319	29	11	141	49	9	170	33	4	50	50	19.7
Heavy rails	The Company does not use heavy rails.															
Total . . .	5	295	11	29	760	24	22	316	43	17	800	36	219	1013	135	...

Number of train-miles : 32 623 000.
Total number of fractures : 325.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 62.

	Light rails :	*Medium rails :*	Remarks
Netherlands Railways. *(Continued.)*			
A. — Percentage of fractures in the respective portions of the rails :			
a) Covered by the fishplates	60 %	50 %	
b) Clear of the fishplates	40 %	50 %	
B. — Percentage of fractures according to the appearance of the fracture :			
a) Fresh and clean fracture through the whole of the rail section :			The attention of the permanent way staff is not yet sufficiently directed to noticing fractures with silvery oval marks.
1. With silvery oval mark 2. Without silvery oval mark	46 %	64 %	
b) Fractures, part of which is old and much rusted, *extending* to the outer surface of the foot or head of the rail :			
1. Rusted part in the foot	48 %	32 %	
2. Rusted part in the head	1 %	4 %	
c) Fractures with much rusted part *not extending* to the outer surface of the foot or head of the rail	5 %	...	
d) Number of pieces into which the rail is broken : 2	78 %	78 %	
— — — — 3	20 %	22 %	
— — — — 4	2 %	...	

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	[illegible]	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Dutch Indies Railway Company.														Miles.		English tons.
Light rails: 25.7 kgr. (51.8 lb. per yard)	...	...	...	...	...	...	...	...	...	...	...	...	1	28	22	12.2

Number of train-miles : 3 077 040.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2

Fractures at the joint : 1; outside the joint : none.
No silvery oval mark.
Rail broken into 4 pieces.
The longitudinal fractures were old and extended between bolt holes, whereas the transverse breaks from head to foot were new.

LENGTH OF THE VARIOUS SECTIONS OF TRACK :

Rails of 25.7 kgr.	(51 8 lb. per yard)	DM	45 km. (28.0 miles).
" 25.7 "	(51 8 lb. ")	G/S	219 km. (136.0 ").
" 26.5 "	(53.4 lb. ")		Not stated.
" 27.8 "	(56.0 lb. ")		93 km. (57.8 miles).
" 29.8 "	(60.1 lb. ")		40 km. (24.9 ").
" 33.5 "	(67.6 lb. ")		228 km. (141.7 ").
" 37.2 "	(75.0 lb. ")		69 km. (42.9 ").
" 38.0 "	(76.6 lb. ")		160 km. (99.4 ").
" 41.0 "	(82.7 lb. ")		19 km. (11.8 ").
			Total 873 km. (542.5 miles).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PORTUGAL. Portuguese Beira Alta Railway.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	13	156.7	51.53	14.3

Number of train-miles : 566 280.
Total number of fractures : 13.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 142.6.

Remarks. — 1. No breakages at the joints ; 2. No data available for the classification of the fractures according to the appearance of the section. The broken rails were of 30 kgr. (60.5 lb. per yard) section.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Portuguese Railway Company.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	591	874.6	419.8	16.7

Number of train-miles : 8 309 598.
Total number of fractures : 591.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 441.9.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COLONIES. Port and Railways of Lourenço Marques.																English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	3	253	7.36	14.8

Number of train-miles : 606 450.
Total number of fractures : 3.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 31.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
RUMANIA.																
State Railways.																
Light rails	57	6 487	5.46	55	6 487	5.26	96	6 487	9.196	107	6 487	10.24	2802	6 487	268.415	17.7
Medium rails	44	514	53.14	15	514	18.11	[illegible]	514	7.24	2	514	2.41	...	514	...	19.7
Total. . .	101	7 001	8.964	70	7 001	6.212	102	7 001	9.053	109	7 001	9.674	2802	7 001	248.952	...

Number of train-miles : 35 259 070.

Total number of fractures : 3 184 + 226 = 3 410.

Total length of single track : 7 001 miles.

Fractures at the joint : 796.

Fractures outside the joint : 2 614.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 600.9.

226 fractures occurred in rails of unknown age.

Our records do not enable us to determine the length of single track for each class of rails according to age nor to classify the fractures according to the appearance of the section.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SWEDEN.		Miles.														
State Railways.																
Light rails	45	(1)	(2)	41	...	...	27	...	...	59	...	...	166	...	...	17.2
Medium rails	109	399	169.8	...	...	...	...	...	...	...	...	...	...	...	...	17.2

Number of train-miles : 19 637 940.
Total number of fractures : 447.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 141.5.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Göteborg-Borås and Borås-Alfvesta Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :	...	3.2 (3)	...	2	20.0 (3)	...	...	26.1 (3)	...	...	1.2 (3)	...	...	111.8 (4)	...	13.8

Number of train-miles : 301 208.
Total number of fractures : 2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trafikförvaltningen Göteborg-Dalarne-Gäfle.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :	1	117.4	5.3	2	85.7	14.5	1	53.9	11.1	1	51.0	36.6	2	133.6	14.0	12.3
Medium rails :	...	36.7	...	3	99.4	18.7	1	80.8	7.7	...	80.2	...	...	...	...	17.0
Total	1	154.1	4.0	5	185.1	16.8	2	136.7	9.1	1	131.2	13.9	2	133.6	14.9	...

Number of train-miles : 3 417 600.
Total number of fracture : 12.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 21.8.

(1) Length of single track : 5 345 miles. (2) Number of fractures per 625 miles for the whole of the light rails : 39.3.
(3) 41.18 kgr. (83 lb. per yard). — (4) 32 kgr. (64.5 lb. per yard).

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
Halmstad-Nässjö Railway.	No fractures in 1929. Maximum axle load : 19 English tons. Number of train-miles : 873 290.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kalmar Railway.											Miles.			Miles.		English tons.
Light rails : 34 kgr. (68.5 lb. per yard).	...	...	...	..	...	...	...	...	...	...	16.2	...	...	129.9	...	17.7
Number of train miles : 473 724. No fractures in 1929.								Running lines : 120.5 miles. Sidings : 25.6 miles.								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nordmark-Klarälfvens Railway.		Miles.												Miles.		English tons.
Light rails	1	106	5.8	...	...	...	...	...	...	...	...	...	4	106	23.5	4.73
Number of train-miles : 375 126. Total number of fractures : 5.										Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 82. 842						
Nässjö-Oskarsham Railway.	No breakages in 1929.															
Nora-Bergslagen Railway.	No fractures reported in 1929.															

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stockholm-Västerås-Bergslagen Railway.											Miles.			Miles.		
Light rails : 40.5 kgr. (81.1 lb. per yard.)	...	...	...	...	...	...	...	...	...	...	...	...	3	268.4	6.9	...
Medium rails : 43.5 kgr. (87.7 lb. per yard).	...	...	...	...	...	...	...	...	...	...	29.8	...	...	...	...	...

Number of train-miles : 132 917.
Total number of fractures : 3

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 14.0.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trafikaktiebolaget Grängesberg-Oxelösund Järnvägar								Miles.			Miles.			Miles.		English tons.
Light rails	...	...	...	...	...	...	...	4	...	...	9.6	...	9	195.2	28.7	...

Number of train-miles : 1 294 046.
Total number of fractures : 9.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 43.23.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Västergötland-Göteborg Railway.																English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Locom. : 7.1 Wagons : 8.4

Number of train-miles : 689 706.

No fractures.

DÉSIGNATION DES ADMINISTRATIONS ET DES RAILS.	Rails âgés de :															Poids maximum des essieux.
	Moins de 5 ans.			5 à 10 ans.			10 à 15 ans.			15 à 20 ans.			Plus de 20 ans.			
	Nombre de ruptures.	Longueur de voie simple de cette catégorie.	Nombre de ruptures par 1 000 km. ou par 625 milles.	Nombre de ruptures.	Longueur de voie simple de cette catégorie.	Nombre de ruptures par 1 000 km. ou par 625 milles.	Nombre de ruptures.	Longueur de voie simple de cette catégorie.	Nombre de ruptures par 1 000 km. ou par 625 milles.	Nombre de ruptures.	Longueur de voie simple de cette catégorie.	Nombre de ruptures par 1 000 km. ou par 625 milles.	Nombre de ruptures.	Longueur de voie simple de cette catégorie.	Nombre de ruptures par 1 000 km. ou par 625 milles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SWITZERLAND. Federal Railways.																English tons.
Light rails : Total : 1 584.5 miles.	3	...	...	1	...	...	2	...	...	6	...	...	211	...	...	20.1
Medium rails : Total : 2 009.5 miles.	37	...	...	28	...	...	54	...	...	45	...	...	106	...	...	20.1
Total : 3 594.0 miles.	40	...	...	[illegible]	...	...	56	...	...	51	...	...	317	...	...	...

Number of train-miles : 24 142 110.
Total number of fractures : 493.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 126.9.

Note. — We are unable to indicate the length of track in 5 classes according to the age of the broken rails.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Berne Alpine Railways: Berne-Loetschberg-Simplon. *a*) Loetschberg Line.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	4.50	...	...	0.95	...	...	...	...	5	43.37	71	...	19.21	...	16.2 to 19.7
Medium rails	1	3.84	166	16	3.25	3 200	3	3.29	600	...	9.66	...	...	...	...	19.7
Total. . .	1	8.34	74.6	16	4.20	2 370	3	3.29	600	5	53.03	58.5	...	19.21	...	...

Number of train-miles : 852 278.
Total number of fractures : 25.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 182.

NAMES [illegible] ADMINISTRATIONS [illegible] DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load.
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
b) Erlenbach-Zweisimmen Line.		Miles.												Miles.		English tons.
Light rails: 26 kgr. (52.4 lb. per yard.)	...	1.41	...	...	0.27	...	...	...	...	...	...	...	...	13.09	...	12.51
Number of train-miles: 79 776.																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
c) Spiez-Erlenbach Line.		Miles.			Miles.									Miles.		English tons.
Light rails: 26 kgr. (52.4 lb. per yard.)	...	1.94	...	...	0.71	...	...	...	...	...	...	...	...	3.90	...	12.51
Number of train-miles: 49 476.																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
d) Berne-Schwarzenburg Line.		Miles.			Miles.											English tons.
Light rails: 26 kgr. (52.4 lb. per yard.)	...	1.28	...	...	0.53	...	...	...	...	...	...	...	3	9.10	206	12.51

Number of train-miles: 68 717.
Total number of fractures: 3,

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: 271.

Names of administrations and description of rails	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
e) Gürbethal Line.		Miles.			Miles.			Miles.						Miles.		English tons.
Light rails : 25.75 kgr. (51.9 lb. per yard).	...	4.01	...	...	0.75	...	...	0.34	...	...	...	...	3	14.02	133	12.51

Number of train-miles : 194 279.
Total number of fractures : 3.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 96.

Names of administrations and description of rails	Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
f) Berne-Neuenburg Line. (Direct line.)		Miles.			Miles.			Miles.						Miles.		English tons.
Light rails : 36 kgr. (72.6 lb. per yard.)	...	0.31	...	...	0.45	...	...	0.50	...	...	...	...	4	23.21	108	17.6

Number of train-miles : 289 522.
Total number of fractures : 4.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 85.

Yverdon-Sainte-Croix Railway.	No breakages in 1929. — Maximum axle load : 10.8 Engl. tons. — Number of train-miles : 49 877.
Lausanne-Ouchy Railway.	No fractures occurred in 1929.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CZECHOSLOVAKIA. State Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails	28	572.0	30.4	138	439.1	195.3	198	665.1	185.0	214	1 328.7	100.1	1772	4 630.3	237.8	...
Medium rails	69	646.4	66.3	43	404.8	66.0	96	273.0	218.5	82	453.4	112.4	59	454.9	80.6	...
Total. . .	97	1 218.4	49.5	181	843.9	133.3	294	938.1	194.7	296	1 782.1	103 2	1831	5 085.2	233.7	...

Number of train-miles : 72 794 475.
Total number of fractures : 2 699.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 230.4.

Remark. — The increased number of fractures which occurred in 1929, compared with previous years, is due to the exceptionally severe frost which prevailed in Czechoslovakia from January to March of that year.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
TURKEY. Smyrna-Cassaba Railway and Extension.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	4	272.5	9.1	14.3

Number of train-miles : 617 443.
Total number of fractures : 4.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 40.2.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
URUGUAY. Central Uruguay Railway and Allied Companies.		Miles.						Miles.			Miles.			Miles.		English tons.
Light rails:																
60.5 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	1	35.4	17.554	15.22
65 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	8	678.7	7.324	15.22
80 lb. per yard	...	170.3	...	...	...	...	...	28.8	...	3	66.9	27.868	2	13.5	92.285	15.22
Total.	...	170.3	...	...	...	...	...	28.8	...	...	66.9	...	11	727.6	9.394	...

Number of train-miles : 2 569 375.
Total number of fractures : 14.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 33.85.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															Maximum axle load.
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
YUGOSLAVIA State Railways. (Standard (4 ft.-8 1/2 in.) gauge lines.)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	245	461.8	329.6	44	334.7	81.6	33	275.6	74.4	261	494.5	328.0	1706	2 639.4	401.6	9.8 to 15.7
Medium rails	5	139.6	22.3	4	8.2	303.9	36	112.8	198.3	34	160.3	131.7	62	136.3	282.7	14.8
Total. . .	250	601.4	258.3	48	342.9	86.9	69	388.4	110.3	295	654.8	279.9	1768	2 775.7	395.8	...

Number of train-miles : 22 729 613.
Total number of fractures : 2 430.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 664.3.

	Light rails.	Medium rails.
A. — Percentage of fractures in the respective portions of the rails covered by the fishplates.	23.8 %	69.0 %
— — — — clear of the fishplates	76.2 %	31.0 %
B. Percentage of fractures according to the appearance of the fracture:		
a) Fresh and clean fracture through the whole of the rail section:		
1° With silvery oval mark.	44.4 %	28.9 %
2° Without silvery oval mark.	29.0 %	24.6 %
b) Fractures, part of which is old and much rusted, extending to the outer surface of the foot or head of the rail:		
1. When the rusted part is in the foot.	12.2 %	12.7 %
2. When the rusted part is in the head.	8.9 %	16.9 %
c) Fractures with much rusted portions not extending to the outer surface of the foot or head of the rail.	5.5 %	16.9 %
d) Number of pieces into which the rail is broken: 2	94.9 %	95.6 %
— — — — — 3	3.8 %	4.4 %
— — — — — 4	0.4 %	...
more than 4	0.9 %	...

CURRENT PRACTICE.

[656.1 & 656.2.]

The new "Ro-Railer", London, Midland and Scottish Railway.

Figs. 1 to 5, pp. 465 to 467.

(From *The Railway Gazette.*)

On 22 January there was demonstrated at Redbourn, on the London Midland & Scottish Railway branch line between Harpenden and Hemel Hempsted, a new motor vehicle designed for use on both road and rail service. It is known as the « Ro-Railer », and has been built by Karrier Motors Limited, of Huddersfield, to the requirements of Mr. J. Shearman, Road Motor Engineer, London Midland & Scottish Railway. By the courtesy of the railway company we have been privileged to attend the demonstation and to reproduce the accompanying particulars and photographic illustrations.

The vehicle, which marks an entirely new departure in passenger transport, has a seating accommodation for twenty-six. The body has been built by Cravens Railway Carriage & Wagon Co. Ltd., of Sheffield, the road wheels are equipped with Goodyear tyres, and the Lang Wheel Company has been responsible for the rail wheels. While the present vehicle is intended for purely passenger service, the same principle can be applied to goods transport.

In its general appearance the vehicle differs very little from an ordinary road vehicle, but the buffers and draw gear at both ends and the arrangement of the lamps, to enable the « Ro-Railer » to carry appropriate lights when driven on the rail in either direction, give it an individual note, while the observant will also see the flanged rail wheels mounted on the axles on the inner sides of the road wheels. The pneumatic-tyred road wheels are mounted on eccentrics fitted to outer extensions of the rail wheel axles. When running on the road the road wheels are locked in a position concentric to the axle. When the vehicle is to be run upon rails it is driven to a place where the road has been made up level to the head of the rail. Then, with the rail wheels directly over the rails, it is driven forward for a few yards to a point where the made-up road is tapered off, so letting the rail wheels gradually come in contact with the rails and take the weight of the « Ro-Railer » off the road wheels, which are then raised clear of the rails, by half a turn of the eccentric mounting, and locked to the chassis frame by a pin. When running on the rails the road wheels do not revolve.

When it is desired to go from the rail to the road the operation just described is simply reversed. In the ordinary way the complete change-over should be carried out in less than five minutes; under test conditions the operation with a four-wheeled « Ro-Railer » has been effected

Fig. 1. — « Ro-Railer ».

Fig. 2. — In road service.

in 2 1/2 minutes. The vehicle demonstrated was fitted with an engine developing a maximum horse-power of 120 and the transmission scheme includes a supplementary gearbox to give increased speed on long railway runs at low engine speed.

This first « Ro-Railer » has the seats staggered to give increased confort, and some of the rear seats fold up in order to afford luggage accommodation. One ingenious detail is the device by which the entrances, on both sides, are made adaptable for either ground or platform levels. This coach is heated by the « Thermo-Economic » hot air system. A sanding gear for use on rails is also provided.

Various applications of system.

The system is applicable to any type of motor vehicle, either passenger or goods, and to tractors and truck trailers. The range in goods vehicles is from 30 cwt. up to 10 tons; for passenger work, small 20-seater buses or high-capacity double-decked three-axled vehicles can be built on the principle. No special equipment is necessary for effecting the change, all that is required being the levelling up of the ground to the top of the rails for a distance of a few yards. «Ro-Railers» can be attached to any train and detached and proceed as a road vehicle as required.

Designed principally for use on branch lines, especially those where the towns and villages lie some distance from the railway, the « Ro-Railer » will meet a definite need, but its use is by no means confined to that sort of work . There are possibilities of using the scheme for week-end traffic to the coast in which it would not only relieve traffic congestion on the roads but speed up the rate of travelling.

Advantages of « Ro-Railer ».

From the point of view of passenger traffic the avantages of the « Ro-Railer » are four in number :

1. Low running cost. Owing to the smaller tractive effort necessary, petrol consumption will be reduced while tyre costs and other maintenance charges will be lessened.

2. Safer travelling. While running at railway speeds the vehicle will be protected by the same system that has made British railway travel the safest in the world. On short tests, speeds of 50 m. p.h. have obtained, and that was not the limit by any means.

3. Comfort and improved visibility, when compared with average branch-line train; comfort on road equal to similar type of vehicle.

4. Journeys shortened and the payment of heavy tolls avoided by railing the vehicle at convenient points. From the point of view of goods traffic there is, in addition to the advantages already mentioned, a further one.

5. Traffic can be actually door to door without transferring the load at any point during transit.

The following table summarises the principal data concerning the new « Ro-Railer »:

Horse power of engine (6 cyl.).	65-110 (R. A. C. rating 37.2)
Chassis wheelbase	17 ft. 1 in.
Road wheel track	6 ft. 3 1/2 in.
Size of tyres	Front 36 in. × 6 in. Rear 42 in. × 9 in.
Rail gauge	4 ft. 8 1/2 in.
Top gear ratio (road)	7 to 1
Top gear ratio (rail)	4.2 to 1

Fig. 3. — Method of bringing road wheels into use.

Fig. 4. — Adjusting wheels. Note wooden ramp for lifting road wheels.

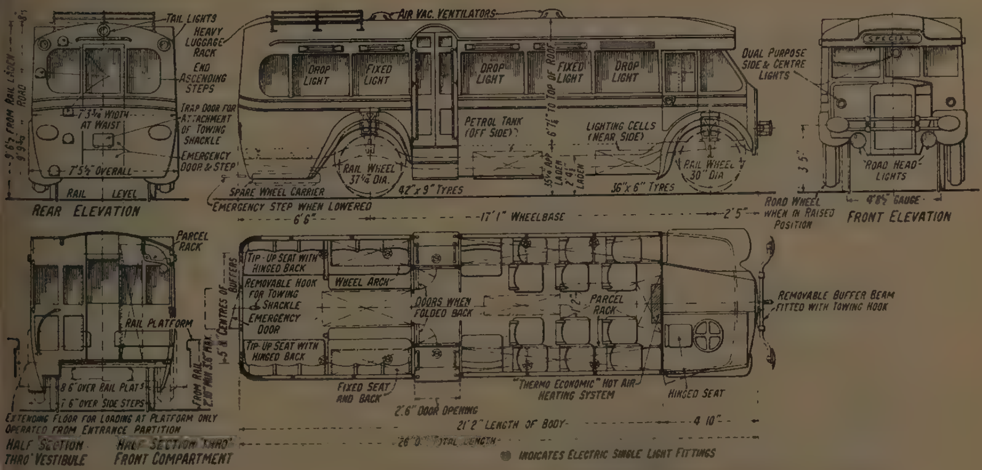

Fig. 5. — Elevations and plan of 26-seater London Midland & Scottish Railway Karrier « Ro-Railer ».

Maximum speed (road) . . .	60 miles per hour.
Maximum speed (rail)	75 miles per hour.
Petrol consumption (road). . .	8 miles per gallon.
Petrol consumption (rail) . . .	16 miles per gallon.
Load capacity	26 passengers or 3 tons net.
Overall length	26 ft.
Overall width	7 ft. 5 1/2 in.
Overall height (road)	9 ft. 9 3/4 in.
Overall height (rail). . . .	9 ft. 6 1/2 in.
Floor to roof height	6 ft. 4 1/4 in.
Unladen weight (complete) . .	7 tons 2 cwt. 2 qrs.

Inside the railway industry there is a possible use for vehicles of this type in conveying men and materials to a point where line construction or repairs are required. The vehicle could be taken either by road or rail to the most convenient point for unloading and be moved immediately from the running lines, thus avoiding any interference with traffic. However one looks at it, the « Ro-Railer » is an innovation which is fraught with very great possibilities.

MISCELLANEOUS INFORMATION.

[656 .253 (.42)]

Automatic train control in England.

In England the Public Authorities have paid much attention to the question of automatic train control which was examined by a Special Committee in 1922. The question was taken up again in 1927 when a new Committee was set up by the Ministry of Transport and its report has just been published.

This report is very interesting. Those entrusted with the task of drawing it up were chosen from amongst the most experienced and competent to deal with the matter and they proceeded to make an extensive and thorough inquiry. The Committee consulted and heard the points of view of many of the officers and members of the staff of the railways, representatives of the Railwaymen's Union, as also those who had up-to-date information concerning the methods of control adopted by the railways of the United States. Furthermore some hundred and fifty descriptions or proposals put forward by inventors or others were examined, though only a few were reserved for mention in the report. With the assistance of the Railway Companies, uniform arrangements were sought for, which would be applicable to all, both as regards the permanent way and locomotives.

The Committee confirms the opinion previously expressed that signalling and working methods have enabled a high standard of safety to be reached in England. New protective measures with the object of remedying any failure on the part of the engine-driver will involve expenses which must be taken into account when considering the extra security obtained; furthermore they must not involve any hindrance to the traffic, which has become very considerable on certain lines, and the methods extolled must be applicable to all lines.

Statistics of accidents are given and commented upon. They relate to two periods : one of ten years ending 30 September 1921; the other of eight years ending 30 September 1929. They prove that the number of train accidents is not increasing, and, on the other hand, that the proportion of cases in which automatic control would have been efficacious is decreasing, the percentage falling from 36.8 % to 29.2 % in passing from the first to the second period. The number of those injured in passenger train collisions in cases where automatic control would have helped the engine driver is about 25 % of the total number of victims of train accidents.

The Committee points out certain improvements which have already been made, which, without making it impossible to misinterpret signals, do increase the safety : daylight signals with coloured lights lit electrically, more powerful light given by signal lamps, improved visibility due to a revisal of the location and height of signals, the substitution of yellow for red lights for distant repeater signals.

As far as the prevention of accidents due to disregarding signals is concerned, opinion is unanimous in recommending supplementary safety measures. Automatic stopping or reduction of speed are not always required, but simply supplementary indications to remind the engine-driver of the presence of a signal, together with other measures such as better signals in better positions, detonator placers, trap-points, etc.

Railway officers and employees are usually in agreement as regards the application of protective measures to distant signals, but the greater number consider that if both express and slow trains are to be taken into consideration, home signals also must be protected. In the opinion of all those consulted, it is a question of special cases, for the solution depends upon the traffic, and the frequency of bad atmospheric conditions. A study of the accidents that have occurred during the

last eight years shows that for preventive methods to be sufficent, they must include the protection by appropriate means of all distant signals and certain chosen home signals.

Like its predecessor the Committee considers that the cab signal should be acoustic, and not visual and it is averse to the adoption of acoustic apparatus placed beside the track.

If the necessity of braking is foreseen at the home signals and the corresponding distant signals, the Committee do not consider a full application of the brakes to be necessary for the first on lines with semaphore signals. But in the case of signals acting as both distant and home signals (signals with more than two aspects) the problem is costly to solve.

This report briefly reviews the different systems or classes of systems which have been tried or made use of, or merely proposed. It gives an appreciation of these from the point of view of safety, strength, expense, the possibility of adapting them to conditions prevailing in England, and also the extent to which their general application may be considered.

The continuous system, based upon induction, which is used in America, gives the most efficacious protection. But installation and upkeep expenses are very high, and on the other hand the apparatus used on the American Railways are based upon the control of the speed without giving any indication as to the position of the signals. In view of the high degree of security already reached in England, the expense would not justify the increase in security that would be obtained. The Committee considers that the system used by the Great Western Railway for more than twenty years is up to the present the only system which gives satisfactorily the indications « warning » and « clear » at distant signals and which can be recommended as satisfying the exigencies of the British Railways.

Under the heading « Recommendations » the report indicates what seem to be the most useful methods. These are classed *under direct methods*, such as the various automatic means of warning the engine-driver, even of acting on the brakes, and *indirect methods* which include all other means by which safety is increased.

For two-aspect distant signals on lines with mechanical signalling, the direct method may consist in giving the driver an acoustic warning of the nearness of a signal; a moderate application of the brakes can easily be added in the case of a stop signal, if air is used to work the acoustic apparatus : this is *acoustic control*. This can be arranged or completed so as to give a different acoustic signal according to whether the signal is at safety or danger. The Commission fixes the necessary standard dimensions for the ramps, the plunger shoe, and the minimum loading gauge for rolling stock.

The most suitable position for the ramp is in the middle of the track, if any position is to be generalised; but an exception must be made in the case of electrified lines with a third central rail, which are usually underground railways already having a control system. The protection of home signals is chiefly concerned with signals at important positions where acoustic alarm and the automatic control of the distant signal might fail. The appliances which should be used in this case are of another order, such as catch points or derailers, traps with or without sand drags, or detonator placers.

Among the indirect methods there are first of all the devices installed on locomotives for throwing the smoke and steam out of the line of sight, and the rational determination of the location of the signals, and then an increase of the illuminative power of the signal lights. The report lays stress on this last point and points out the characteristics of oil and electric lamps which show a very marked progress.

Among the proposed improvements mention must be made furthermore of certain modifications to the rules and regulations of the block system; to the conditions of the acceptance of a train up to the home signal that has come up behind a train stopped at the inner home signal; to the tests that the stok-

ers charged with the duties of engine-driver must undergo; to the use of fogmen.

In a general way, the Committee expresses its preference for direct methods. However it must always fall to each Company to decide in what direction to look for greater safety according to the conditions that prevail upon its lines. Those with an approved system of automatic control should extend it.

An appendix deals with the extent of the application of automatic train control systems in the United States, and the costs of installation. Another appendix gives statistical information and the cost per unit which would serve as a basis to calculate the expense that would be incurred by a general application of these in England.

E. M.

[385. (06.111]

OFFICIAL INFORMATION

ISSUED BY THE

Permanent Commission
of the International Railway Congress Association

QUESTIONS

FOR DISCUSSION AT THE CAIRO SESSION (1933)

WITH

THE NAMES OF THE REPORTERS

Ist SECTION : WAY AND WORKS.

I. — The protection of level crossings in view of modern developments in road traffic.

Reporters :

America, Great Britain, Dominions and Colonies, China, Japan and Egypt :

Mr. Newlands (M. A.), chief engineer, London Midland & Scottish Railway; Euston Station, London, N. W.

Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark Finland, Luxemburg, Norway, Sweden and Switzerland :

Mr. Collin, Directeur du Contrôle de l'Exploitation technique au Ministère des Travaux Publics de France; boulevard Saint-Germain, 244, Paris.

Other countries (Germany, Bulgaria, Greece, Rumania, Poland, Czechoslovakia, Turkey, Yugoslavia, etc.) :

Mr. Miszke (A.), ingénieur, chef du bureau des études et des projets au Ministère des Communications de Pologne; rue Langiewicza, 14, Warsaw.

II. — The use of mechanical appliances in the permanent way maintenance and in track relaying.

Reporters :

United States of America, Great Britain, Dominions and Colonies, China and Japan:

Mr. Thomson (F. M.), district engineer, Missouri-Kansas-Texas Lines; Denison, Texas, U. S. A.

Mexico, Central and South America, Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway, Sweden and Switzerland :

Messrs. Mendizabal Fernandez (D.), ingénieur en chef du service des voies et travaux au Chemin de fer Madrid-Saragosse-Alicante; Estación de Atocha, Madrid, and

Garcia Garin (J.), chef du service du matériel fixe des voies et travaux des Chemins de fer du Nord de l'Espagne; Estacion del Norte, Madrid.

Other countries (Germany, Poland, Czechoslovakia, Bulgaria, Greece, Rumania, Yugoslavia, Turkey, Egypt, etc.) :

Mohamed Bey Kamel El-Kishin, ingénieur divisionnaire, Chemins de fer de l'Etat égyptien; Zagazig (Egypt).

III. — The relationship between the vehicle and the track, to ensure safety at high speeds :

A) Weight of vehicles per axle, position of the centre of gravity, wheel arrangement, layout to facilitate running through curves.

B) Track resistance. Widening of gauge. Radius of curves. Superelevation. Transition curves. Points and crossings. Check rails.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Dr. Okhodo (S.), director of the Bureau of maintenance and improvement,

Dr. Matsunawa (S.), chief of the Railway Research Office, and

Dr. Asakura (K.), chief of the rolling stock Section : *all three* of the Department of Railways, Government of Japan; Tokyo.

Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland :

Herr Prof. Baumann (H.), Direktor bei der Reichsbahn; Lammstrasse, 19, Karlsruhe, and

Herr Jähn (F.), Reichsbahnoberrat, Reichsbahn-Zentralamt; Hallesches Ufer, 35-36, Berlin, S. W. 11.

Other countries (Belgium, France, Italy and their Colonies, Luxemburg, Czechoslovakia, Poland, Bulgaria, Rumania, Greece, Turkey, Egypt, Yugoslavia, etc.):

Mr. Deyl (Hynek), conseiller ministériel et chef du département IV/5 au Ministère des Chemins de fer de Tchévoslovaquie; Prague.

2nd SECTION : LOCOMOTIVES AND ROLLING STOCK.

VI. — Methods to be used to increase the mileage run by locomotives between two repairs including lifting.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Sir Henry FOWLER, K. B. E., assistant vice-president for works, London Midland & Scottish Railway (member of the Permanent Commission); Derby.

Germany, Denmark, Finland, Norway, Spain, Netherlands, Portugal and their Colonies, Sweden and Switzerland :

Herr STUDENT (E.), Reichsbahndirektor, Deutsche Reichsbahn Gesellschaft; Vossstrasse, 35, Berlin, W. 8.

Other countries (Belgium, France, Italy and their Colonies, Luxemburg, Poland, Czechoslovakia, Bulgaria, Greece, Rumania, Yugoslavia, Turkey, Egypt, etc.) :

Mr. KLATOVSKÝ (R.), ingénieur, conseiller ministériel et chef du département V/1 du Ministère des chemins de fer de Tchécoslovaquie; Prague II.

V. — Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Mr. WITHINGTON (S.), electrical engineer, New York, New Haven & Hartford Railroad; Newhaven, Conn. (U. S. A.).

Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden :

Messrs. LEBOUCHER, ingénieur en chef des services techniques du matériel et de la traction, Chemins de fer du Midi; boulevard Hausmann, 54, Paris (9e), and
JAPIOT, ingénieur en chef adjoint du matériel et de la traction des Chemins de fer de Paris à Lyon et à la Méditerranée; boulevard Diderot, 20, Paris (12e).

Other countries (Germany, Poland, Switzerland, Czechoslovakia, Bulgaria, Greece, Rumania, Yugoslavia, Turkey, Egypt, etc.) :

Mr. HUBER, ingénieur conseil des Chemins de fer Fédéraux suisses; Neumünster-Allee, 12, Zurich.

VI. — All-metal rolling stock : carriages and wagons. Use of light metals and alloys. Use of autogeneous welding.

Reporters :

America, Great-Britain, Dominions and Colonies, China and Japan :

Mr. Gresley (H. N.), C. B. E., chief mechanical engineer, London & North Eastern Railway (member of the Permanent Commission); King's Cross Station, London, N. I.

Germany, Bulgaria, Denmark, Finland, Norway, Netherlands and Colonies, Rumania, Sweden, Czechoslovakia, and Turkey :

Herr Dähnick (E.), Reichsbahnoberrat, Deutsche Reichsbahn Gesellschaft, Zentralamt; Hallesches Ufer, 35-36, Berlin, S. W. 11.

Other countries (Belgium, Spain, France, Italy, Portugal and their Colonies, Luxemburg, Switzerland, Yugoslavia, Egypt, Greece, etc.) :

Mr. Mariani (R.), ingénieur, chef de service au service du matériel et de la traction, Chemins de fer de l'Etat italien; Viale Principessa Margherita, 52, Florence (12).

3rd SECTION : WORKING.

VII. — Allocation of freight rolling stock. Investigation into the turn-round of goods vehicles. Separation of the elements included in it. Methods of reducing the period of turn-round.

Reporters :

Belgium, Spain, France, Italy, Portugal and their Colonies, Luxemburg and Switzerland :

Mr. Gaeremynck (O.), ingénieur principal au service de l'exploitation de la Société Nationale des chemins de fer belges; 17, rue de Louvain, Brussels.

Germany, Denmark, Finland, Great Britain, Dominions and Colonies, Sweden, America, China and Japan, Norway, Netherlands and Colonies :

Mr. van Rijckevorsel (F. H.), ingénieur, chef de service des transports des Chemins de fer néerlandais; Maliesingel, 76, Utrecht.

Other countries (Poland, Czechoslovakia, Bulgaria, Rumania, Yugoslavia, Greece, Turkey, Egypt, etc.) :

Mr. Ark (F.), inspecteur de la Direction Générale des Chemins de fer du Royaume de Yougoslavie; Belgrade.

VIII. — Organisation for carrying small consignments of goods and the most suitable methods for their delivery with the least delay. Use and selection of fixed and mechanical transhipping plants.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan, Belgium, France, Spain, Netherlands, Portugal and their Colonies, Switzerland, Denmark, Finland, Luxemburg, Norway and Sweden :

Messrs. HAUTERRE, chef de l'exploitation adjoint des Chemins de fer de l'Etat français, 13, rue d'Amsterdam, Paris (8e), and

MERMONT (M.), inspecteur général du mouvement du Chemin de fer de l'Est français; 13, rue d'Alsace, Paris (10e).

Other countries (Germany, Italy and Colonies, Poland, Czechoslovakia, Bulgaria, Rumania, Yugoslavia, Greece, Turkey, Egypt, etc.) :

Mr. FETTARAPPA (C.), ingénieur, inspecteur en chef au service de l'exploitation des Chemins de fer de l'Etat italien, Rome.

IX. — Automatic train control and train stop. Track equipment. Locomotive fittings. Methods used for repeating signals on the locomotives. Devices intended to ensure the attention of the drivers.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Mr. CROOK (G. H.), assistant to signal engineer, Great Western Railway; Reading, England.

Belgium, Spain, France, Italy, Netherlands, Portugal and their Colonies, Denmark, Finland, Luxemburg, Norway and Sweden :

Mr. VLAÏKOFF (V.), ingénieur des signaux, Chemins de fer de l'Etat bulgare; 2, place de la Gare, Sofia.

Other countries (Germany, Poland, Czechoslovakia, Bulgaria, Greece, Rumania, Yugoslavia, Turkey, Egypt, etc.) :

Mr. STÄCKEL (W.), Reichsbahndirektor, Mitglied der Hauptverwaltung der Deutschen Reichsbahn-Gesellschaft; Vosstrasse, 35, Berlin, W. 8.

4th SECTION : GENERAL.

X. — Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits.

Reporters :

Belgium, Spain, France and their Colonies, Great Britain, Dominions and Colonies, Luxemburg, Netherlands, Portugal and their Colonies :

Messrs. Soulez (E.), ingénieur en chef attaché à la direction de l'exploitation du Chemin de fer du Nord français, rue de Dunkerque, 18*bis*, Paris (10e), and

Bloch, ingénieur en chef des services du matériel et des ateliers du Chemin de fer de Paris à Orléans; boulevard de la Gare, 41, Paris (13e).

Denmark, Norway, Sweden, Finland, Germany, Switzerland, Czechoslovakia, Bulgaria, Greece, Rumania, Yugoslavia, Turkey, Poland :

Mr. Mereutza, sous-directeur général, Chemins de fer de l'Etat roumain (member of the Permanent Commission); 118, Calea Victoriei, Bucarest.

Italy and its Colonies and other countries :

Messrs. Tosti (L.), inspecteur en chef supérieur du service du personnel et des affaires générales, Chemins de fer de l'Etat italien; Rome, and

Valeri (C.), ingénieur, inspecteur en chef supérieur du service du matériel et de la traction, Chemins de fer de l'Etat italien; Florence.

XI. — Competition between or joint working of railways and airways, or railways and roadways.

An investigation from the technical, commercial and contractual point of view.

Reporters :

America, Great Britain, Dominions and Colonies, China and Japan :

Mr. Cox (E. C.), traffic manager, Southern Railway; Waterloo Station, London S. E. 1.

Other countries :

Messrs. Villamil (F. P.), chef de la division commerciale du Chemin de fer du Nord de l'Espagne, Estación del Norte; Madrid, and

d'Ocón Cortes (E.), ingénieur au service commercial du Chemin de fer Madrid-Saragosse-Alicante; Estación de Atocha, Madrid.

5th SECTION : LIGHT RAILWAYS AND COLONIAL RAILWAYS.

XII. — Co-ordination of operation as between heavy and light railways.

Reporters :

Continent of Europe :

Mr. Jacobs (L.), directeur général adjoint, Société Nationale des Chemins de fer vicinaux de Belgique; rue de la Science, 14, Brussels.

Other countries :

Camel Bey Chehata, directeur adjoint du service des marchandises des Chemins de fer de l'Etat égyptien; Cairo, Egypt.

XIII. — Use of rail motor cars on secondary railway lines.

Reporters :

Italy and Colonies, Africa, (British Dominions and Colonies excepted), Mexico, Central and South America :

Messrs. La Valle (E.), inspecteur en chef, directeur du bureau central de conseil technique près l'Inspectorat général des chemins de fer, tramways et automobiles; Rome, and

Mellini (E.), ingénieur, inspecteur supérieur de l'Inspectorat général des chemins de fer, tramways et automobiles; Rome.

Continent of Europe (except Italy) :

Mr. Level, directeur de la Compagnie générale de voies ferrées d'intérêt local; 18, rue de Dunkerque, Paris (10e).

Great Britain, Dominions and Colonies, United States of America, China and Japan:

Mr. Forster (A. D. J.), assistant railway Commissioner, New South Wales, Government Railways, Box 29 A., G. P. O. Sydney, N. S. W. Australia.